More to Spot – New Insights into Dobble or: Size Matters, Color not

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***Abstract*— Dobble or Spot It! is a game created by Blue Orange Games for two up to eight players. In the game the players have to find symbols in common between cards. The mathematics of the game is surprisingly interesting and several papers have been published on it. However, the works concentrate on the creation of dobble decks. Based on 30 recorded games, this study mainly investigates whether and how symbol size and color of the symbols affect the recognition of common symbols.**

I. Introduction

Dobble or Spot It! Is a game created by Blue Orange Games for two up to eight players. In the game the players have to find symbols in common between cards. We played a game that contains a deck of 55 cards with eight symbols on each card. Each player receives a pile with the same number of cards. One card remains in the middle of the table. Now each player compares the top card of their individual pile with the card in the middle of the table. As soon as they find a matching symbol, they may discard the card, which now becomes the new card in the middle of the table. The first player to discard all cards wins the round.

The game is particularly interesting because there seems to be no chance. There is no dice and since all pairs of cards have exactly the same number of matching symbols, which is one, so there are no better or worse cards. Who will win this game depends only on the talent or ability to find such pairs quickly.

The authors showed at the G4G15 [6] that in the real course of the game, players name significantly more pairs of the identical animal in a row than would be expected from a purely random ordering of the cards. The explanation for this effect is that by naming the symbol they found, players' attention is focused on finding that symbol again. Even if this does not always occur before naming another pair, it will result in an increased probability of this event. This shows that the game is not entirely free of chance.

This work will show that there are some other aspects that have an influence on quickly finding the right matching symbol. Thus, the game is even more not completely independent of luck.

This raises the question of whether there are other factors that can influence players' attention in a similar way. Based on a series of experiments with 30 games, in which a total of 1,334 animal names were mentioned, we will investigate whether the size of the respective animal representations plays a role. Accordingly, we will also determine whether the basic color of the animals influences the likelihood of their mention.

II. Dobble Mathematics

A complete Dobble deck consists of $n = 57$ cards. Each Dobble card contains $k = 8$ different symbols, and each pair of these cards has exactly one symbol in common. A total of $n = 57$ different symbols are required. In the US, there exists a variation of the game called Spot It! Junior, which only has $k = 6$ symbols per card. The game consists of 31 cards [2]. In general, it can be shown that a game with k symbols per card cannot have more than $n = k \cdot (k-1) + 1$ cards and symbols.

Interestingly, Heemstra showed in 2014 that it is impossible to create a Dobble for $k = 7$ with 43 cards [5]. Games with 11 and 12 symbols per card have been calculated, whether a game with 13 symbols per card is possible is still unknown [1]. Another strange fact about Dobble is, that geometry can be used, too, to answer these questions. In fact, Dobble has almost exactly the same structure as a geometrical object called a finite projective plane. This connection was described by Donna Dietz in 2013 [3]. However, there are also Dobble games that are not a finite projective plane [4]. A very nice mathematical description of Dobble is provided by the thesis of Christian Kathrein from the University of Graz [8].

In fact, the games on the market contain two cards less than a complete Dobble. and in this work all games and calculations will be made on a deck of 55 cards. A comment by Guillaume Gille-Naves, a former member of the development team for the French version of Dobble, explains that the game has 55 cards (instead of 57) for marketing purposes and to ensure that the rules of the game could be printed on extra cards without exceeding the manufacture limitation of 60 cards [12].

III. Evaluating Dobble Games

The game was played with a version of Dobble with 55 cards, each of which contained 8 of the 57 animals used as symbols. Two cards were therefore missing for a complete set. This resulted in $n^1 = 42$ animals (group 1) being represented 8 times each, $n^2 = 14$ animals (group 2) being represented 7 times each, and $n^3 = 1$ animal (the zebra) being represented exactly 6 times (group 3). The 55 cards were assigned unique numbers, and the animals depicted on each card and their areas were determined.

Each Card were scanned at a specified resolution. The images were then vectorized using Inkscape software by applying an edge detection algorithm [7]. For some images, minor edge detection errors had to be corrected manually. For each image (each animal), the area of the animal in pixels could now be determined. As a bonus, a DrawADobble coloring book was created from the outlines of the animals, allowing users to draw their own Dobble. It is attached as Appendix 1. In Addition, the DrawADobble contains the two missing cards designed by the authors.

This area determination was performed for all animals with indices $i = 1, \ldots, 57$ on all 55 cards. $A_{i,1}, \ldots, A_{i,8}$ denotes the sizes of the animals in group 1, $A_{i,1}, \ldots, A_{i,7}$ denotes the sizes of the animals in group 2, and $A_{i,1}, \ldots, A_{i,6}$ denotes the six sizes of the zebra (group 3). For each pair of cards, the respective animal and the corresponding pair $(A_{i,k_1}, A_{i,k_2}$ are stored.

The average area of the symbols is 4281.9 pixels. However, there is a large deviation: the smallest symbol is the pig with an average area of 2122 pixels, while the largest symbol is the dove with an average area of 6342 pixels. The standard deviation is smallest for the crocodile at 763 and largest for the dove at 4923.

In addition to the previous practice of recording the animals mentioned during a game, the order of the cards discarded was also noted after each game. This made it possible, with the stored card information, to both check the list of animals mentioned in the game and determine the individual size of each of the two images of the matching pair.

In total, data from 30 games were recorded, played by seven people from three generations (aged 5, 7, 14, 16, 44, 46, and 71) in different lineups. There were 16 games with two players, 13 games with three players, and one game with four players.

The rows of noted symbols are not the same length, as the game ends as soon as one of the players wins. A Dobble play with two players ended after an average of 47.7 symbols called (standard deviation 5.5), a play with three players after an average of 43.4 symbols called (standard deviation 4.2). The corresponding t-test rejects the hypothesis of equal expected values with an error probability of $\alpha = 0.05$, i.e. we have proven that an additional player shortens the game length.

A total of 1,334 animal names were mentioned over the course of the 30 games, with the lowest number (10), as expected, being recorded for the zebra, which is depicted only six times. The median number of mentions was 23, with the mean being 23.4. The two most frequently mentioned animals were salmon (38) and hedgehog (44). Both animals have an above-average average area.

Table I shows the called out symbols of the example game played by 4 persons. This game ended with the victory of one of the children after the 36th symbol was called out

Table 1: noted symbols of an example game

No.	Symbol	No.	Symbol	No.	Symbol	No.	Symbol
1	lion	10	**hedgehog**	19	**frog**	28	**dolphin**
2	parrot	11	**hedgehog**	20	**frog**	29	penguin
3	duck	12	jellyfish	21	**goat**	30	pelican
4	camel	13	bunny	22	**goat**	31	**duck**
5	kangaroo	14	sloth	23	hippo	32	**duck**
6	**cat**	15	orca	24	tiger	33	**hippo**
7	**cat**	16	wolf	25	crab	34	**hippo**
8	**fish**	17	**bat**	26	sheep	35	**donkey**
9	**fish**	18	**bat**	27	**dolphin**	36	**donkey**

It is immediately noticeable that in the example game it occurs several times that the same symbols are called out several times in direct succession and thus form tuples in the table (highlighted in bold here).

A statement about the probabilities of such multiple mentions should be made, for example depending on the number of players, their playing strength, or the group to which the named animals belong. To do this, however, we first need the probability of mentioning each animal. The probability $p^{(1)}$ with which an individual animal of the first group is even mentioned at the beginning of the game can be determined as follows. Because at the beginning there are $\binom{55}{2}$ equally probable pairs of cards, of which $\binom{8}{2}$ both contain the animal of group 1 , we have:

$$p^{(1)} = \frac{8 \cdot 7}{55 \cdot 54} = \frac{28}{1485} = 0.01886.$$

Accordingly, the probabilities for the 14 animals in group 2 and for the zebra (as the only animal in group 3) are:

$$p^{(2)} = \frac{7 \cdot 6}{55 \cdot 54} = \frac{21}{1485} = 0.01414,$$

$$p^{(3)} = \frac{6 \cdot 5}{55 \cdot 54} = \frac{15}{1485} = 0.01010.$$

These probabilities allow the calculation of the expected frequency for the mention of each animal, which is 25.2 for animals of group 1, is 18.9 for animals of group 2, and 13.5 for the zebra. The subsequent comparison with the observed frequencies and the performance of the chi-square goodness-of-fit test decide whether to accept or reject the hypothesis that the observations are actually compatible with these calculated probabilities. Without removing the outlier (the hedgehog) with the extreme frequency of 44, the chi-square test (with $\chi^2 = 80.4,\ df = 56$ and a p-value of $p = 0.0180$) rejects the null hypothesis. If this outlier is removed, the test (with $\chi^2 = 67.0,\ df = 55$ and ap-value of $p = 0.1291$) no longer contradicts the existence of the assumed distribution.

In the 2024 work [6], the occurrence of events has already been examined. An event was defined as the occurrence of two identical symbols in a sequence of three cards. This is equivalent to the repeated mention of the last mentioned symbol during the course of the game. At that time, the statements referred to the complete Dobble with 57 cards. The question is whether the determined probability for the occurrence of an event of $6/55 = 0.1091$ needs to be modified if it is now a case of Dobble with 55 cards, i.e. if two cards are missing from the complete set. For a solo player, $s = 1$, the probability $P(E_1^j)$ for an event involving an animal from group j is

$$P(E_1^j) = p^{(j)} \cdot \frac{7-j}{53}$$

which yields the Event probability $P(E_1)$ after summing over all animals:

$$P(E_1) = \sum_{j=1}^{3} n^{(j)} \cdot P(E_1^j).$$

If the Event E_s in a game with $s > 1$ players is understood as the possibility that one of the participating players can continue the game by naming the last animal named, then the following applies analogously:

$$P(E_s) = \sum_{j=1}^{3} n^{(j)} P(E_s^j) \quad \text{with} \quad P(E_s^j) = p^{(j)} \left(1 - \frac{\binom{46+j}{s}}{\binom{53}{s}}\right).$$

The numerical analysis yields

$$P(E_1) = 0.1091, \quad P(E_2) = 0.2081, \quad P(E_3) = 0.2977,$$
$$P(E_4) = 0.3788, \quad P(E_5) = 0.4518, \quad P(E_6) = 0.5176$$

and thus confirms that the event probability does not change over the course of the game as long as no information about the game's progress is taken into account.

IV. Does the Size of the Symbols Matter?

It was assumed that the larger the images of the two cards being examined, the easier it is for players to find the corresponding animal on the two cards being examined. To statistically verify this, the recorded sequences of cards laid down in the game were first used to determine which animal i was named in each case and what size the both images, A_{i,k_1} and A_{i,k_2}, were. Based on these 1334 observations from 30 games, empirical estimates for the expected values and variances of the random variables $S_1 = A_{i,k_1} + A_{i,k_2}$, $S_2 = \max(A_{i,k_1}, A_{i,k_2})$, and $S_3 = \min(A_{i,k_1}, A_{i,k_2})$ were determined. We got the means and the empirical standard deviations:
$\overline{S_1} = 9094.2, \quad s_{S_1} = 4308,9,$
$\overline{S_2} = 6007.8, \quad s_{S_2} = 3086.4,$
$\overline{S_3} = 2947.5, \quad s_{S_3} = 1886.6.$

Under the null hypothesis H_0 that the sizes of the depicted animals have no influence on the identification of the matching pair of animals, the expected value for the random variables A_{i,k_1}, A_{i,k_2} is equal to the mean of all areas determined:

$$E(A_{i,k_1}) = E(A_{i,k_2}) = E(A) = \mu_A = 4281.9.$$

Thus $E(S_1) = E(A_{i,k_1} + A_{i,k_2}) = 4281.9 + 4281.9. = 8563.8$. Because of the large difference between this expected value and the observed mean $\overline{S_1} = 9094.2$, we can reject the null hypothesis H_0 with high significance,
$T = \frac{9094.2-8563.8}{4308,9}\sqrt{1334} = 4.5$ with p-value $p =< 3.6 \cdot 10^{-6}$.

Alternatively, 66,000 games, each consisting of 41 cards, were simulated using the MATLAB command 'randperm(55)'. The corresponding area sizes were then evaluated using the same MATLAB algorithm that was also used for the sequences of the 30 actual games played. The following means and empirical standard deviations were obtained from these simulated data:
$\overline{S_1}_{sim} = 8595.4, \quad s_{S_1 sim} = 4137.8,$
$\overline{S_2}_{sim} = 5806.5, \quad s_{S_2 sim} = 2968.3,$
$\overline{S_3}_{sim} = 2788,9, \quad s_{S_3 sim} = 1731.6.$

All three mean values $\overline{S_j}$ of the observed sizes of the identified animals exceed these corresponding values of the simulated data. Since $T = \frac{8595.4-8563.8}{4308.9}\sqrt{1334} = 0.27$, we can assume that the simulation determines the expected values valid under H_0 with sufficient accuracy. Therefore, the above means can be used as expected values. A comparison with the means previously determined from the 30 games and the calculation of the corresponding t-statistics yields
$T_1 = 4.2281$, p-value $< 3 \cdot 10^{-5}$,
$T_2 = 2.4939$, p-value 0.013,
$T_3 = 5.7602$, p-value $< 10^{-7}$,
and contradicts the null hypothesis H_0. The original assumption is thus confirmed with high significance.

The most striking finding is that, with T_3, the size of the smaller animal image has the predominant influence. This shows that the smaller animals are often overlooked.

If we evaluate the data for the games separately according to the number of players, we obtain T and p-values:
for 2 players (747 animal mentions)
$T_1 = 3.6559$ ($p < 3 \cdot 10^{-3}$),
$T_2 = 2.5239$ ($p = 0.012$),
$T_3 = 4.4271$ ($p < 10^{-5}$),
for 3 players (551 animal mentions)
$T_1 = 3.9771$ ($p < 7 \cdot 10^{-5}$),
$T_2 = 1.7810$ ($p = 0.075$),
$T_3 = 6.2446$ ($p < 10^{-7}$),
for 4 players (36 animal mentions)
$T_1 = 4.5496$ ($p < 6 \cdot 10^{-6}$),
$T_2 = 3.2699$ ($p = 0.0011$),
$T_3 = 5.3131$ ($p = 10^{-7}$),

It is noticeable that the significance of the maximum image size T_2 tends to decrease with increasing number of players. This is understandable, since the probability of encountering the larger images increases with the number of animals to be compared.

V. Does the Color Matter?

What other factors might influence a player's ability to spot a pair of matching animals faster than their opponents? Bright, signal colors, especially red and yellow, are often used in everyday life to draw people's attention [11]. Can a similar effect be demonstrated in Dobble? Since the animal images in the game used are characterized by seven clearly recognizable primary colors (blue, brown, green, gray, pink, red, and yellow), the study aims to determine whether, in real-life gameplay, animals of certain colors are mentioned significantly more or less frequently than would be the case with a purely random selection of card pairs.

Of the 57 animals in the game, 6 are blue, 9 brown, 8 green, 14 gray, 6 pink, 6 red, and 8 yellow. It should also be noted that the probability of naming an animal depends on which group it belongs to. Thus, among the 6 blue animals, 5 belong to group 1 (all of which appear in the game with exactly 8 images) and one belongs to group 2 (this is the dolphin, which only appears on 7 cards in the game). Overall, this results in a probability of

$$p_{\text{blue}} = 5 * p^{(1)} + p^{(2)} = 5 * \frac{28}{1485} + \frac{21}{1485} = \frac{161}{1485} = 0.1084$$

that a blue animal will be named. The expected frequency of a blue animal under the hypothesis that the mention is based on a purely random selection of card pairs is therefore $1334 * p_{\text{blue}} = 144.6$. The expected frequencies of the other colors are determined accordingly. In Table II, these are compared with the observed frequencies.

Table 2: expected and observed frequencies

	blue	brown	green	gray	pink	red	yellow
expected	144.6	220.2	194.9	315.3	138.3	125.8	194.9
observed	160	224	194	301	136	120	199

The corresponding chi-square goodness-of-fit test with $\chi^2 = 2.75$, $df = 6$ and a p-value of $p = 0.839470$ provides no indication that one of the colors is preferred or less preferred.

VI. Conclusion

It's obvious that the math behind the game Dobble is exciting. However, most of the papers published so far relate to the creation of Dobble sets.

The game is especially interesting at first sight because luck does not seem to be a component of the game. However, in the work for G4G15 it was shown that the game is not completely free of luck. This is due to the effect anchored in the human psyche that we recognize a symbol that we hear more quickly because the visual and auditory cortex are strongly connected.

This study has now shown that the influence of chance is even greater: even though the coloring of the individual symbols has no influence on how quickly the animals are found, the size of the animals does have a significant influence. However, it depends on luck whether the animal the current player is looking for is depicted as particularly large or particularly small on the card in the hand.

The fact that the colors of the symbols do not play a role in recognizing them as duplicates at speed is somewhat surprising. The effect of signal colors has been extensively researched and scientifically proven. However, it can be assumed that the human brain has to compare the symbols sequentially [13], so it is likely that a route between the symbols on the cards will be followed. Apparently, the largest animal is more likely to be chosen than the most colorful one. It is also likely that the player will move from the first animal to neighboring animals.

Dobble is a fascinating game that even very young children can learn well. The game is also well suited to introducing pupils or students to mathematical problems. In the past, it has already been used in language lessons [10], [9], but it could definitely be used in math courses.

In this sense – Let's play Dobble!

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Appendix 1

Card 1: penguin, seastar, raccoon, dolphin, pig, eagle, hippo, orca

Card 2: dolphin, camel, hedgehog, crocodile, salmon, scorpion, fish, reindeer

Card 3: fish, rooster, seastar, turtle, mosquito, cat, kangaroo, pelican

Card 4: fish, eagle, squirrel, pigeon, zebra, crab, sloth, donkey

Card 5: crab, lion, penguin, turtle, salmon, sheep, wolf, octopus

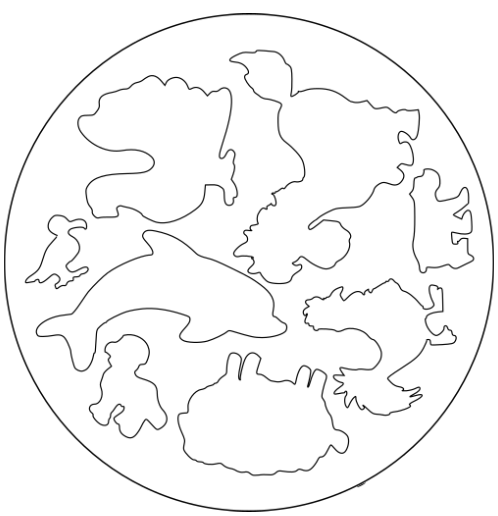
Card 6: wolf, fish, pig, flamingo, seahorse, jellyfish, seagull, grashopper

Card 7: seastar, horse, squirrel, salmon, tiger, parrot, seal, jellyfish

Card 8: salmon, hippo, zebra, rooster, duck, gorilla, owl, grashopper

Card 9: kangaroo, bat, gorilla, camel, kangaroo, penguin, sloth, jellyfish

Card 10: dog, tiger, reindeer, hippo, seahorse, turtle, shark, donkey



Card 11: dolphin, horse, dog, sheep, rooster, polarbear, seagull, pigeon

Card 12: sloth, dolphin, tiger, mosquito, bunny, lion, bear, grashopper

Card 13: seal, kangaroo, duck, donkey, dolphin, wolf, cow, spider

Card 14: panda, parrot, sheep, pig, gorilla, mosquito, donkey, crocodile

Card 15: scorpion, cat, penguin, flamingo, donkey, owl, horse, bunny

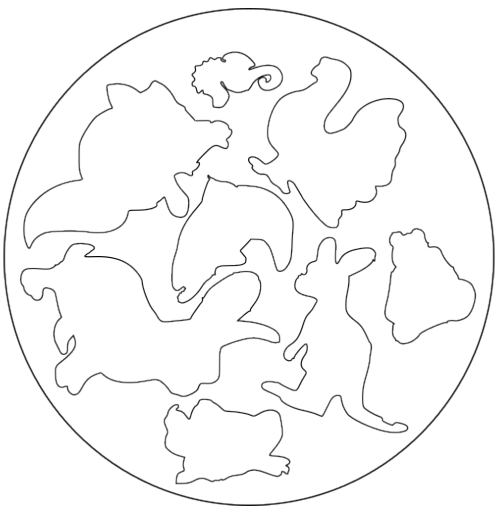
Card 16: bat, wolf, reindeer, mosquito, polarbear, owl, raccoon, squirrel

Card 17: crocodile, flamingo, duck, lion, shark, seastar, bat, pigeon

Card 18: tiger, scorpion, bat, spider, rooster, pig, frog, crab

Card 19: dolphin, gorilla, mouse, buffalo, turtle, flamingo, squirrel, frog

Card 20: gorilla, pigeon, hedgehog, wolf, goat, tiger, cat, orca



Card 21: pigeon, seahorse, raccoon, salmon, kangaroo, panda, frog, bunny

Card 22: polarbear, turtle, crocodile, zebra, jellyfish, spider, bunny, orca

Card 23: pigeon, mouse, grashopper, reindeer, spider, penguin, pelican, parrot

Card 24: horse, sloth, hippo, crocodile, frog, beaver, pelican, wolf

Card 25: panda, sloth, orca, seal, flamingo, reindeer, rooster, octopus

Card 26: tiger, kangaroo, mouse, crocodile, seagull, octopus, owl, eagle

Card 27: bunny, seagull, cow, seastar, beaver, gorilla, reindeer, crab

Card 28: sloth, seagull, turtle, parrot, duck scorpion, raccoon, goat

Card 29: gorilla, raccoon, bear, spider, horse, fish, shark, octopus

Card 30: mouse, jellyfish, raccoon, lion, rooster, hedgehog, donkey, beaver

Card 31: penguin, squirrel, goat, crocodile, bear, rooster, seahorse, cow

Card 32: crab, hedgehog, hippo, bear, flamingo, polarbear, parrot, kangaroo

Card 33: hedgehog, seastar, sloth, buffalo, sheep, owl, seahorse, spider

Card 34: owl, panda, crab, pelican, shark, jellyfish, goat, dolphin

Card 35: goat, hippo, seal, bat, bunny, fish, sheep, mouse

Card 36: panda, horse, bat, grashopper, turtle, hedgehog, eagle, cow

Card 37: orca, pelican, seagull, salmon, bat, bear, cow, donkey

Card 38: reindeer, buffalo, goat, zebra, horse, kangaroo, pig, lion

Card 39: cow, flamingo, pelican, tiger, camel, raccoon, zebra, sheep

Card 40: wolf, bunny, eagle, parrot, shark, camel, rooster, buffalo

Card 41: sheep, scorpion, kangaroo, orca, squirrel, beaver, grashopper, shark

Card 42: grashopper, donkey, octopus, goat, frog, seastar, polarbear, camel

Card 43: seagull, cat, hippo, panda, camel, lion, spider. squirrel

Card 44: orca, seahorse, camel, crab, mouse, mosquito, duck, horse

Card 45: hedgehog, octopus, pelican, bunny, pig, squirrel, dog, duck

Card 46: scorpion, buffalo, jellyfish, cow, hippo, pigeon, octopus, mosquito

Card 47: dog, frog, orca, cow, lion, fish, owl, parrot

Card 48: beaver, pigeon, pig, turtle, owl, camel, seal, bear

Card 49: dog, raccoon, grashopper, crocodile, crab, buffalo, cat, seal

Card 50: duck, panda, tiger, polarbear, fish, beaver, buffalo, penguin

Card 51: sheep, reindeer, jellyfish, cat, frog, eagle, duck, bear

Card 52: polarbear, cow, mouse, pig, sloth, salmon, shark, cat

Card 53: penguin, hedgehog, mosquito, seal, zebra, shark, seagul, frog

Card 54: mosquito, salmon, dog, eagle, flamingo, goat, spider, beaver

Card 55: pelican, seal, lion, polarbear, gorilla, eagle, scorpion, seahorse

Newcard 56: bear, dog, mouse, panda, seestar, scorpion, wolf, zebra (This is one of the two cards missing in the original game.)

Newcard 57: beaver, dolphin, bat, octopus, parrot, seehorse, cat, zebra (This is one of the two cards missing in the original game.)

animal	color	animal	color
bear	brown	salmon	grey
beaver	red	lion	yellow
dolphin	blue	mouse	green
squirrel	brown	seagull	grey
polarbear	blue	mosquito	green
duck	green	hippo	blue
donkey	pink	orca	grey
eagle	brown	panda	grey
sloth	grey	parrot	red
fish	yellow	pelican	yellow
flamingo	pink	pigeon	blue
bat	grey	horse	brown
frog	green	penguin	grey
gorilla	grey	jellyfish	green
grasshopper	green	seal	blue
rooster	red	sheep	blue
shark	grey	turtle	green
bunny	pink	pig	pink
reindeer	brown	seahorse	red
dog	yellow	seastar	pink
hedgehog	brown	scorpion	grey
camel	yellow	spider	grey
cat	red	tiger	yellow
kangaroo	yellow	owl	brown
octopus	pink	raccoon	grey
crab	red	goat	yellow
crocodile	green	buffalo	brown
cow	brown	wolf	grey
zebra	grey		

Table 1: colorcode of all 57 animals