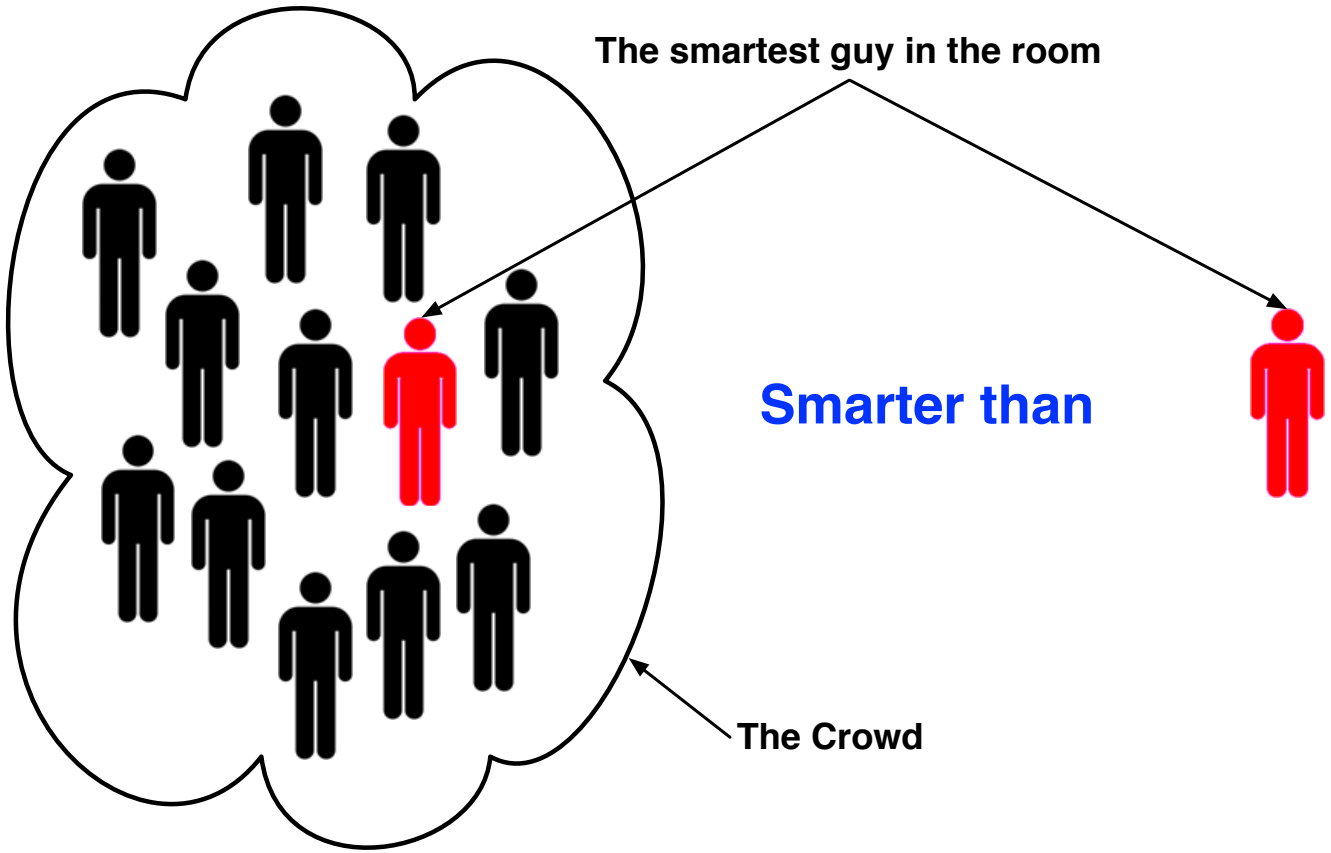
Wisdom of Crowds

DD3364

April 29, 2012

The Wisdom of Crowds



The **collective knowledge** of a *diverse* and *independent* body of people typically **exceeds** the knowledge of **any single individual** and can be harnessed by voting.

The Wisdom of Crowds - Really?

Crowd wiser than **any individual**

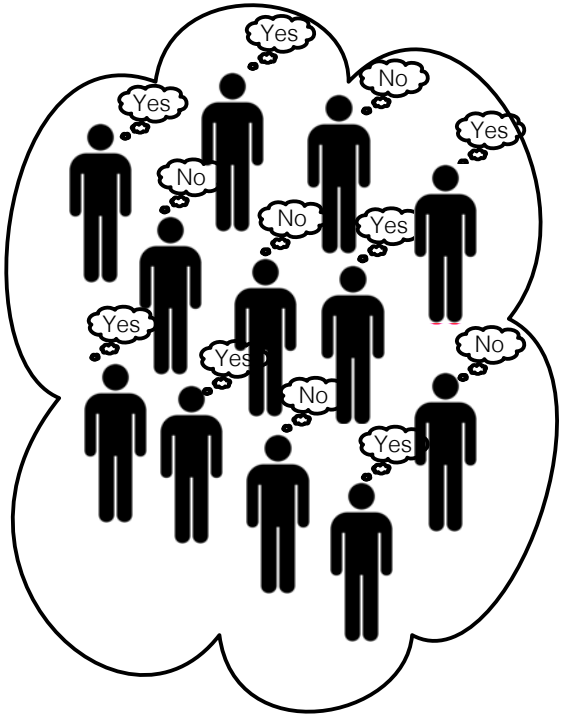
- When ?
- For which questions ?

See **The Wisdom of Crowds** by *James Surowiecki* published in 2004 to see this idea applied to business.

Consider this scenario

Ask each person in the crowd:

Will Mr. X win the general election in country Y?



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MAJORITY answer.

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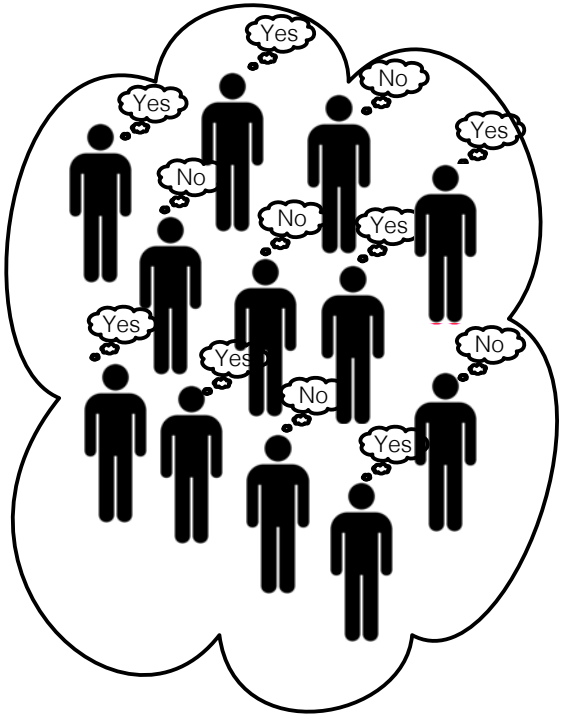

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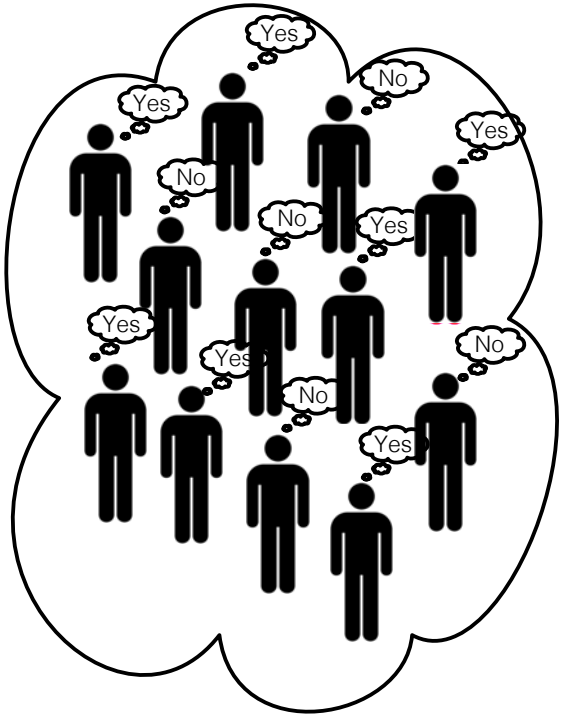

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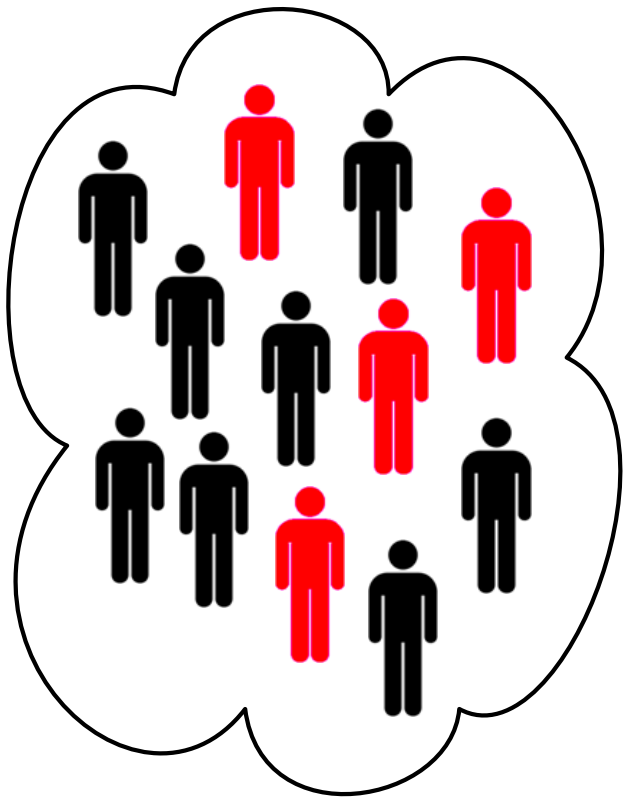

If composition of crowd:

30% **EXPERTS**.
70% **NON-EXPERTS**.

and their level of expertise:

$$P(\text{correct prediction} \,|\, \text{expert}) = p_e$$
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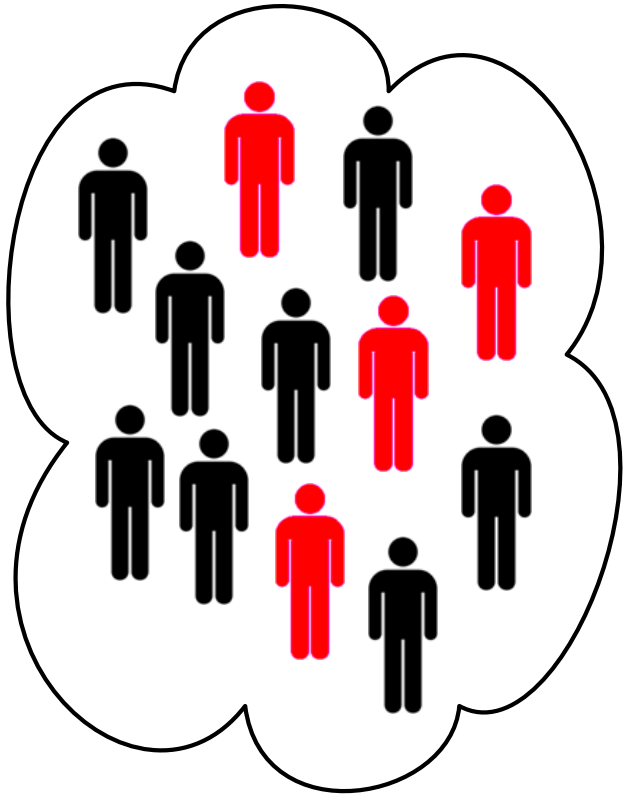

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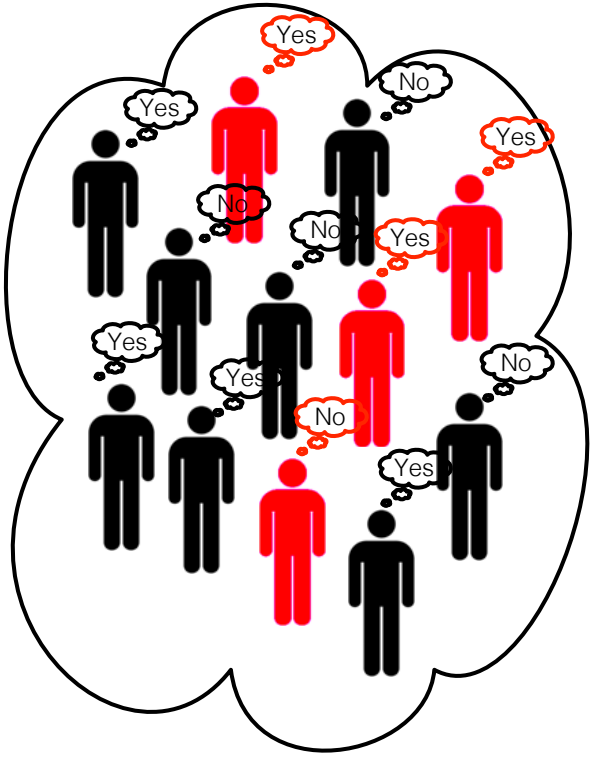

Let $p_e = .8$ and $p_{ne} = .5$

For random person from crowd:

$$P(\text{correct pred.} \mid \text{individual}) = .3\,p_e + .7\,p_{ne}$$
$$= .59$$

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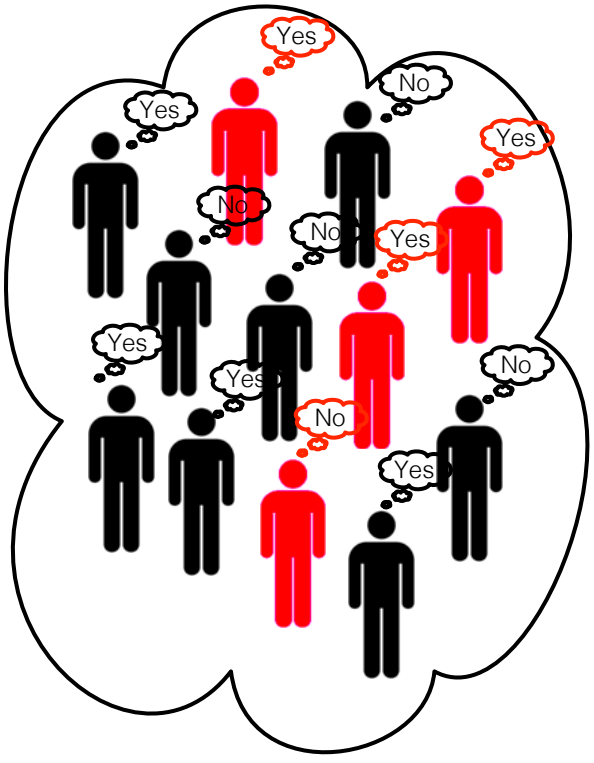

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If crowd contains 50 *independent* **people:**

$$P(\text{correct pred.}|\text{crowd}) = \sum_{k=26}^{50} \binom{50}{k} p_i^k (1-p_i)^{50-k}$$

$$= .8745$$

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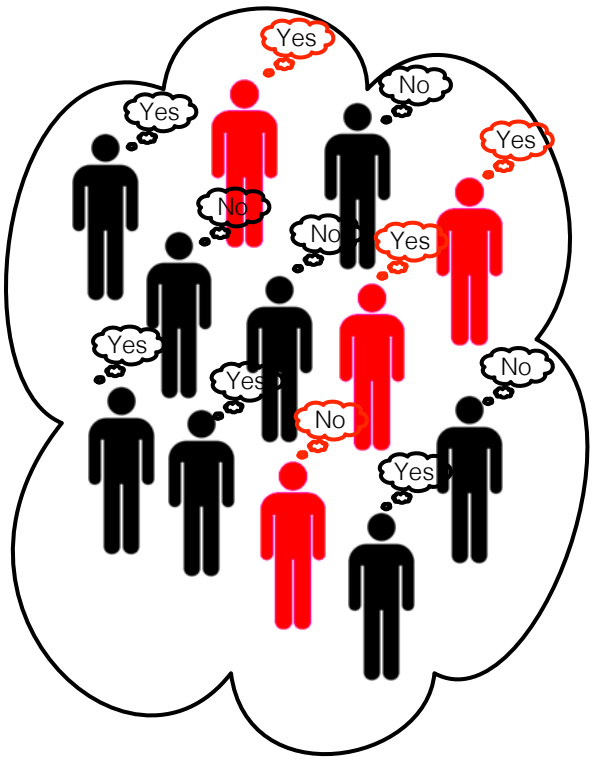

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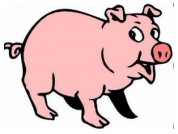
This crowd has made a prediction with probability .875 of being correct which is $> p_e$.

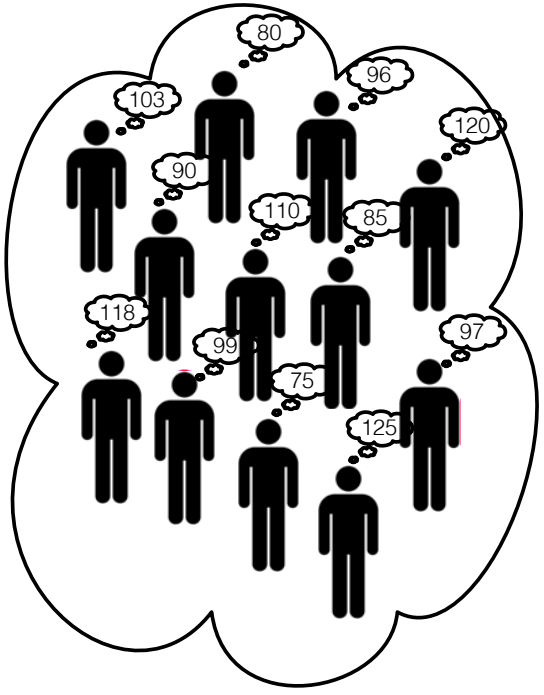
It is wiser than each of the experts!

Another scenario

Ask each person in the same crowd:

How much does the pig weigh?





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AVERAGE of all predictions.

← This crowd predicts **99.8333**.

(The pig weighs 99.8333 kg.)

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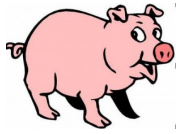
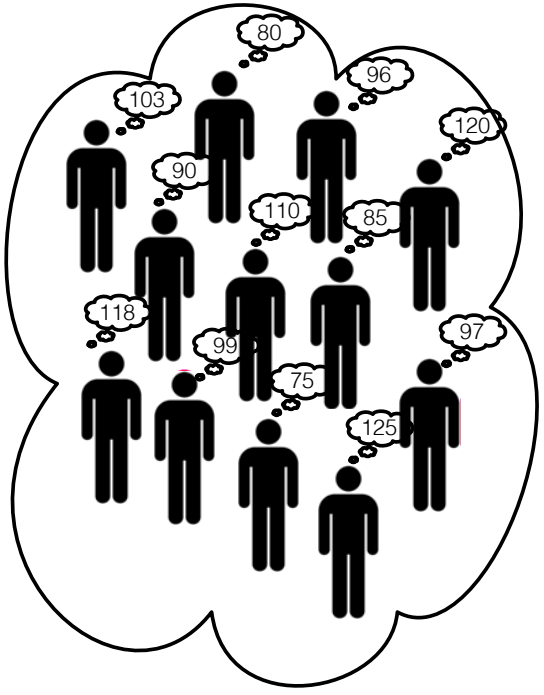
How much does the pig weigh? 



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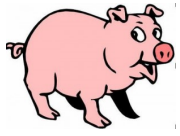
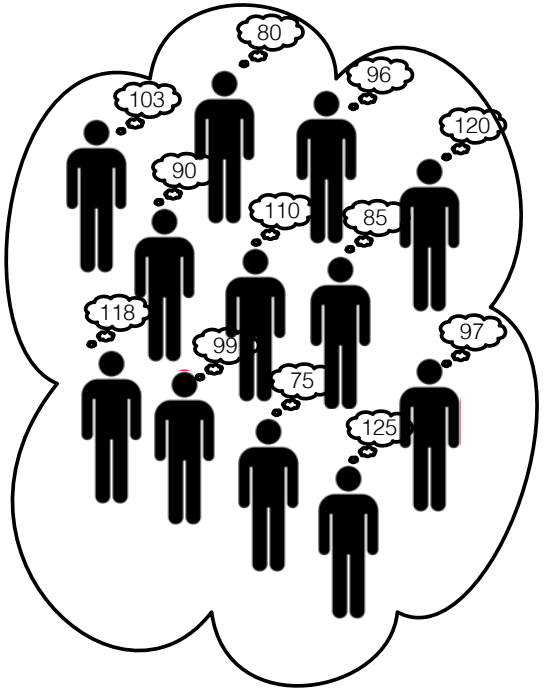
How much does the pig weigh? 



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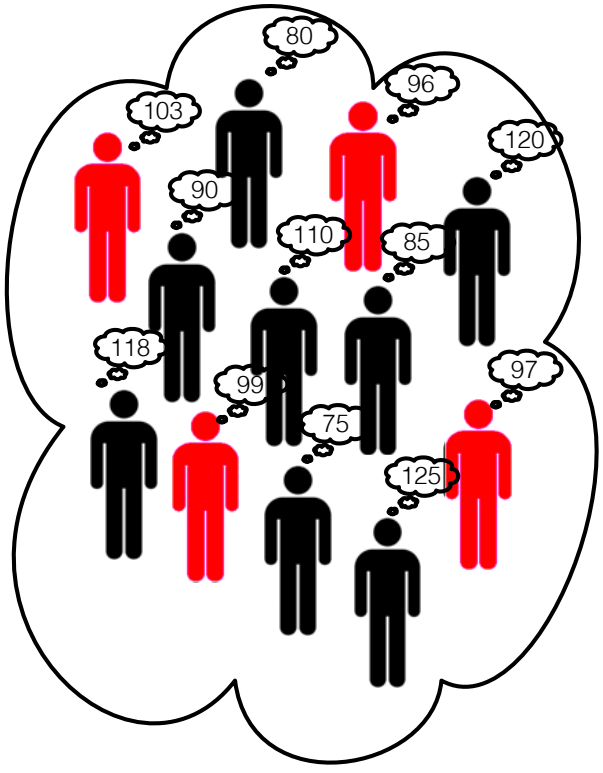

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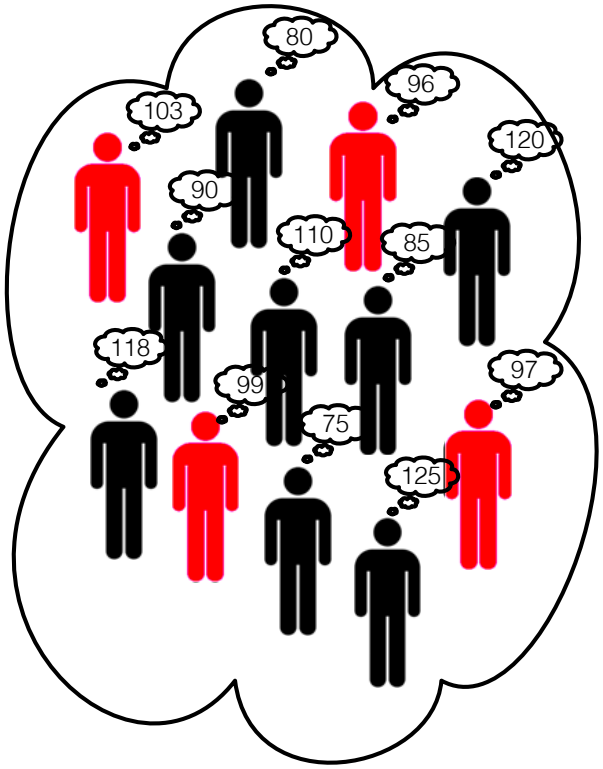

If composition of crowd:

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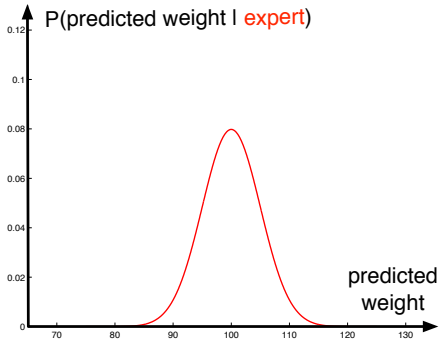
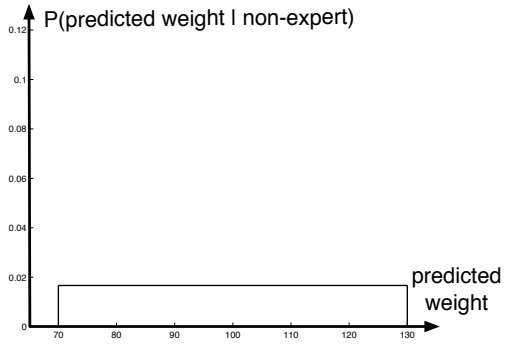
and their level of expertise:

(Say *pig*'s true weight is 100 kg)





$P(\text{pred. weight} \mid \text{expert})$:

$\mathcal{N}(100, 5^2)$

$P(\text{pred. weight} \mid \text{non-expert})$:

$\mathcal{U}(70, 130)$

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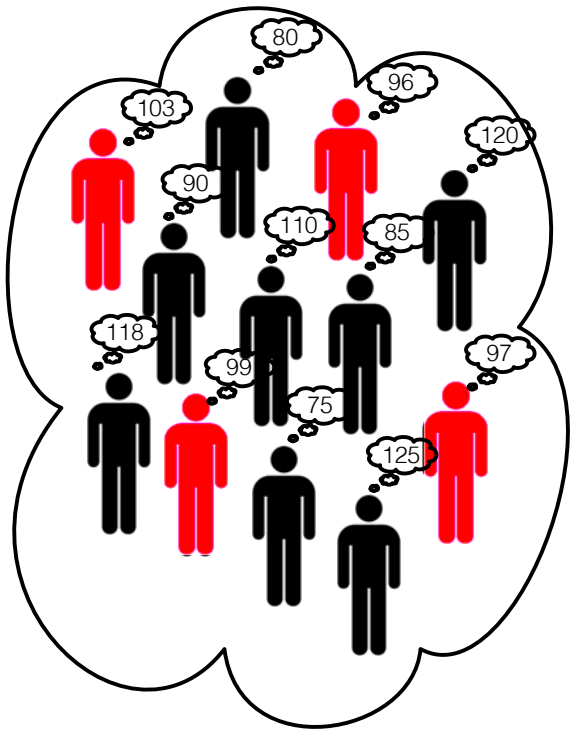

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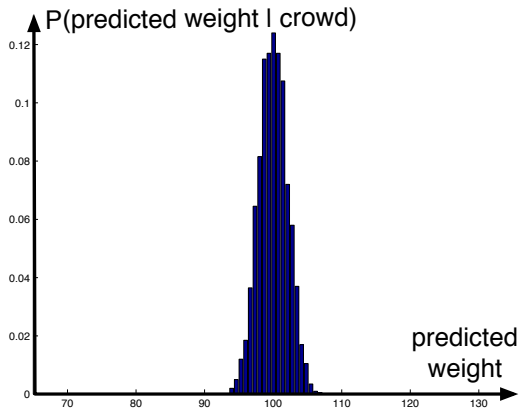

$\Uparrow$

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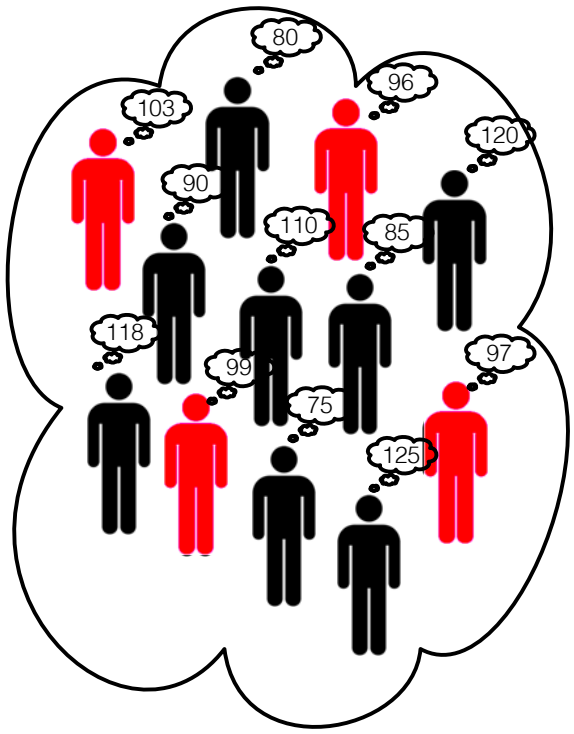

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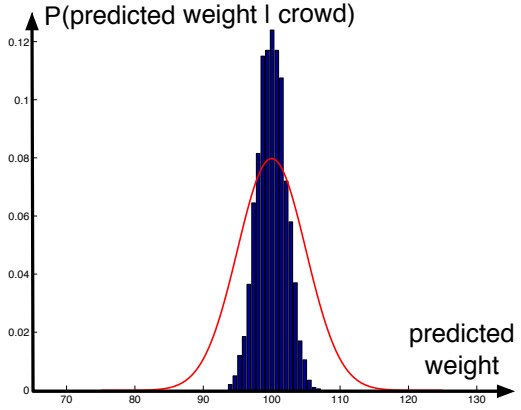

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$P(\text{pred. weight}|\text{crowd})$ **and**
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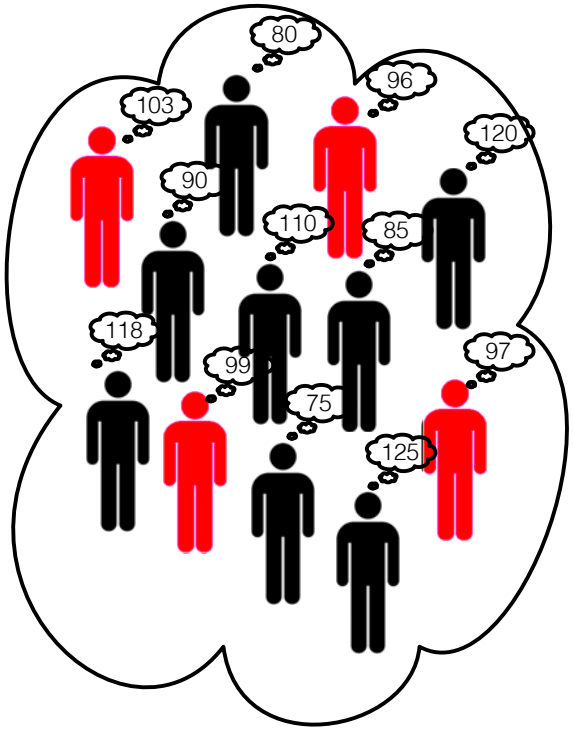

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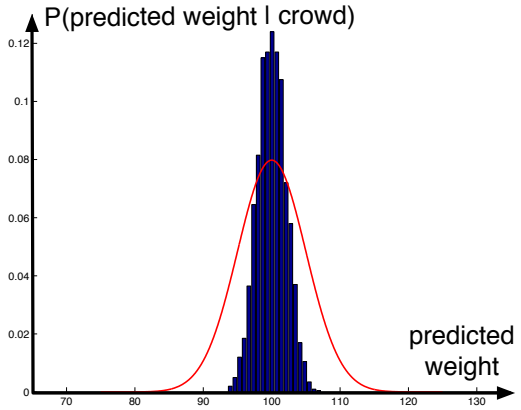

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$P(\text{pred. weight}|\text{crowd})$ **and**
$P(\text{pred. weight}|\text{expert})$

On average this crowd will make better estimates than the experts.

It is wiser than each of the experts!

But....

Why didn't I just asked a bunch of experts??

- Large enough crowd $\Longrightarrow$ high probability a sufficient number of experts will be in crowd (for any question).
- Random selection $\Longrightarrow$ don't make a biased choice in experts.
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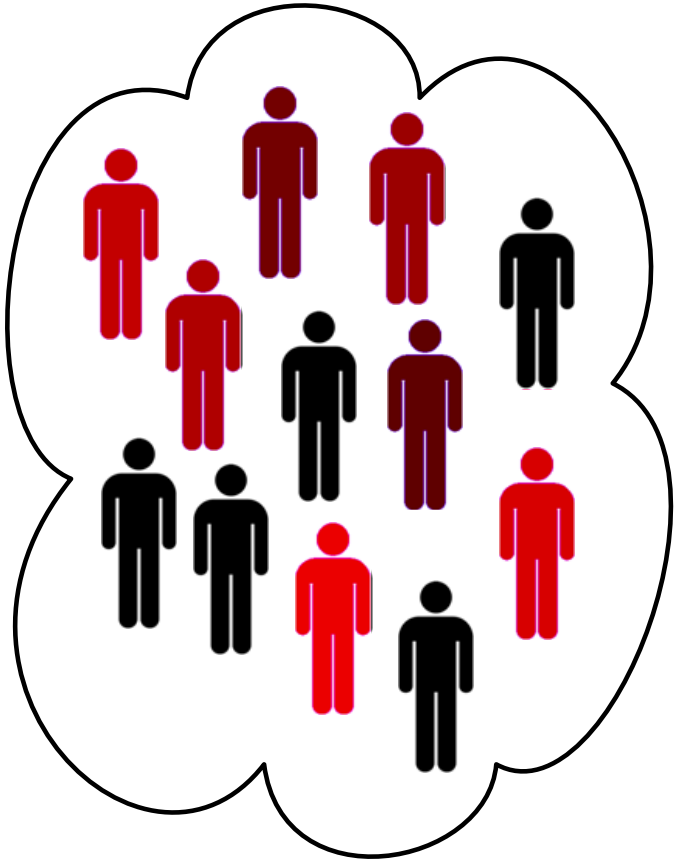
For a random crowd

Given a **random question** expect each **person** to have a **different level** of **expertise**.



Will it rain tomorrow?

$\Leftarrow$ redness proportional to expertise.

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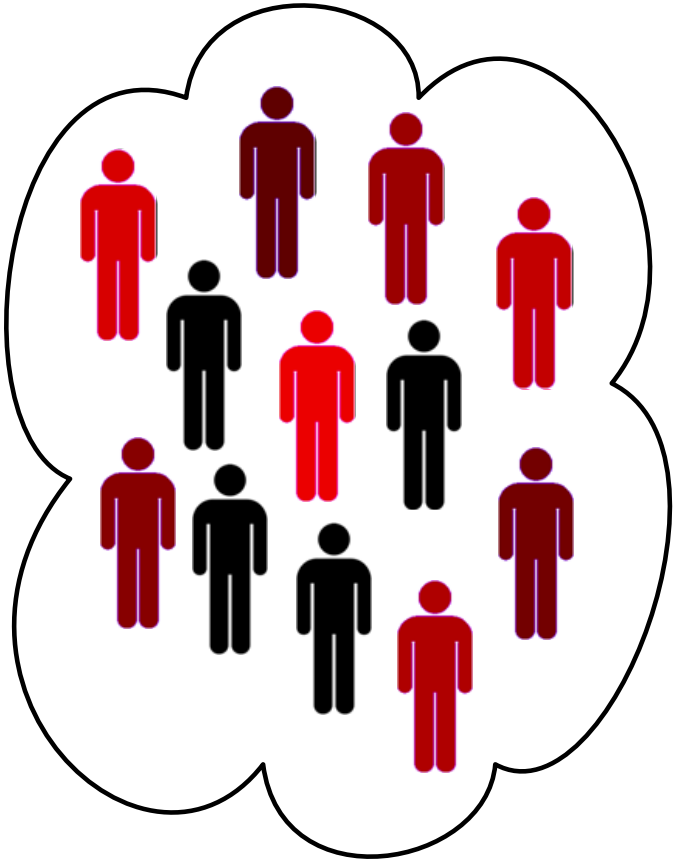

Will Obama be re-elected as president?

$\Leftarrow$ redness proportional to expertise.

What makes a crowd wise?

According to *James Surowiecki* there are four elements required to form a wise crowd

- **Diversity of opinion.** People in crowd should have a range of experiences, education and opinions.
  (Encourages independent predictions)
- **Independence.** Prediction by person in crowd is not influenced by other people in the crowd.
- **Decentralization** People have specializations and local knowledge.
- **Aggregation.** There is a mechanism for aggregating all predictions into one single prediction.

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If this is not adhered to the crowd runs the risk of...

Rational bubbles! Crowds can also be stupid

Rational bubbles have occurred when the crowd has had very bad judgment:

- *Tulip mania*, Netherlands 1630's,
- *Tech stock bubble*, 1990's,
- *Housing bubble*, Ireland in the 2000's,
- *Ponzi schemes*, Ivar Kreuger (famous KTH graduate), Bernie Madoff et al.

See **Extraordinary Popular Delusions and the Madness of Crowds** by Charles Mackay from the 1840's.

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- The non-experts will predict a completely random wrong answer - these will somewhat cancel each other out.
- However, there may be a systematic and consistent bias in the non-experts' predictions.

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  This can lead to...

Wikiality! Crowds can also be stupid

If the crowd does not contain sufficient experts then *truth by consensus* (rather than fact) leads to **Wikiality**!

Term coined by *Stephen Colbert* in an episode of the *The Colbert Report* in July 2006.

Back to machines

Back to machine learning

This course considers different types of classifiers/regressors instead of a crowd of humans.

- None of these classifiers is as clever, flexible or has the wealth of experience as a human **but**
- their simplicity makes them easier to analyze !

Note: sometimes when I write *classifier* the idea also holds for *regressors*.

Back to machine learning

Will exploit *Wisdom of crowd* ideas for specific tasks by

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- aim to combine independent and diverse classifiers.

But will use labelled training data

- to identify the **expert** classifiers in the pool;
- to identify **complementary** classifiers;
- to indicate how to best combine them.