

# Virtual bargaining: The hidden logic of joint action and communication

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Behavioural Science Group

Misyak, J. B., & Chater, N. (2014). Virtual bargaining: a theory of social decision-making. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369.

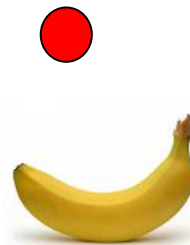
Misyak, J. B., Melkonyan, T., Zeitoun, H., & Chater, N. (2014). Unwritten rules: virtual bargaining underpins social interaction, culture, and society. *Trends in Cognitive Sciences*, 18, 512-519.

Misyak, J., Noguchi, T., & Chater, N. (2016). Instantaneous conventions. *Psychological Science*, 27(12), 1550–1561.

Chater, N. & Misyak, J. (2021). Spontaneous communicative conventions through virtual bargaining. In. S. Muggleton, S. & N. Chater, N. (Eds). *Human-like machine intelligence*. Oxford, UK: Oxford University Press.

1. An example
2. Communication vs. action
3. Communication as coordination
4. Coordination by virtual bargaining

# Inferring communicative intentions from observation: **Version 1**



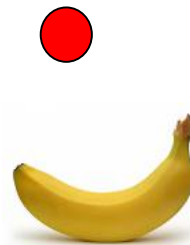








# Common knowledge is crucial: **Version 2**



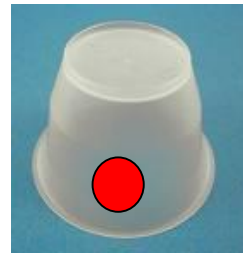
Take 1 or  
more











*If two buckets can be lifted...*

# Inferring communicative intentions from observation: **Version 3**



Take 1 or  
more









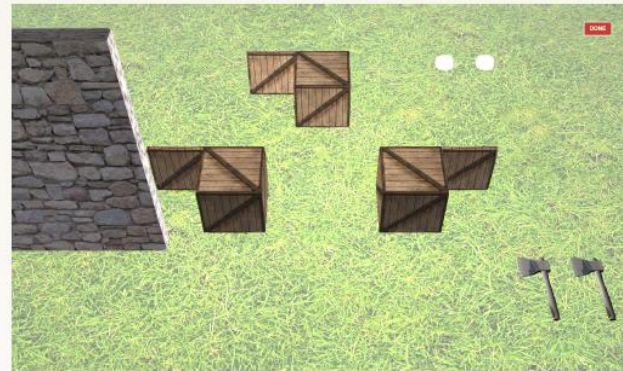


# Experimental stimuli:

Example 1



Sender's view

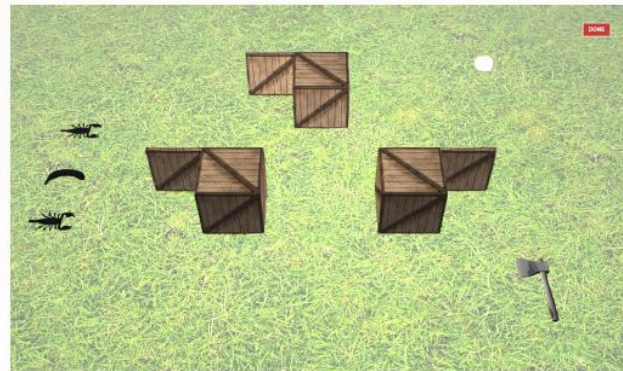


Receiver's view

Example 2



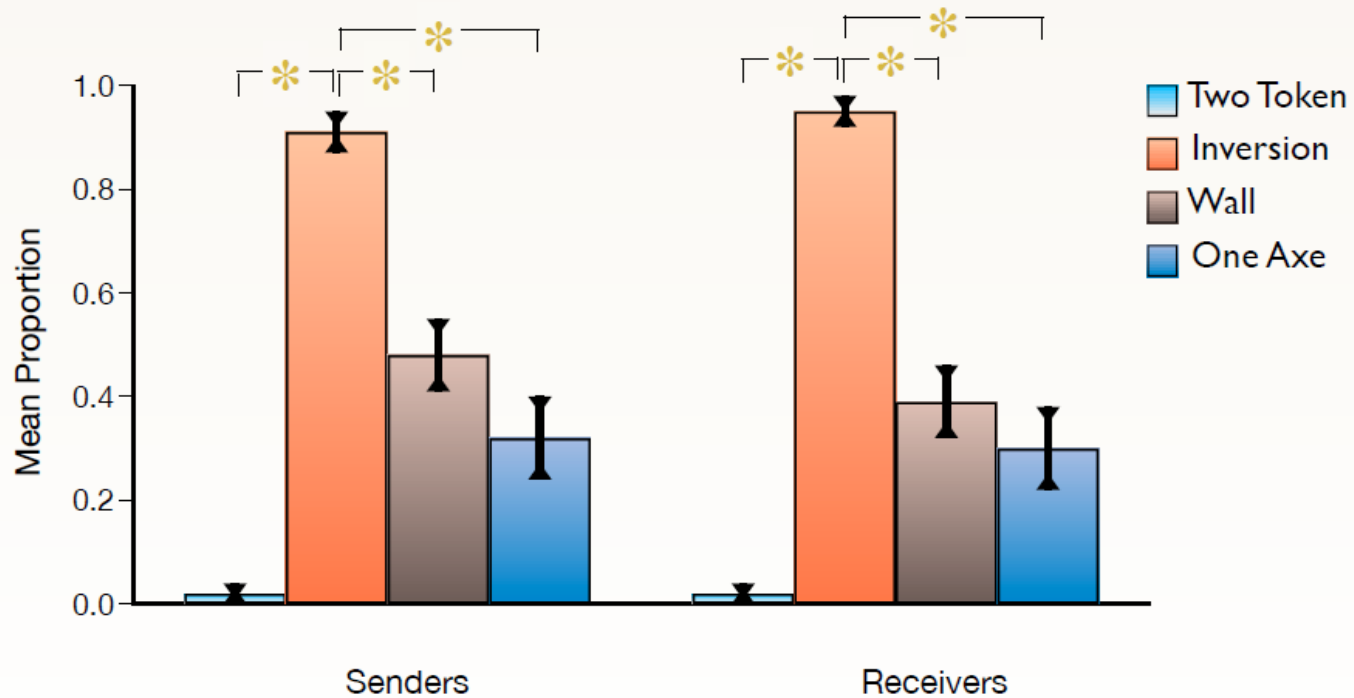
Sender's view



Receiver's view

# Use of the odd-one-out signal

Source: Misyak, Noguchi & Chater,  
*Psychological Science*, 2016



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# Communication and action

- ◎ Communication
  - Information conveyed by signal
  - Some kind of reliable link between signal and world
  
- E.g., domain of information theory



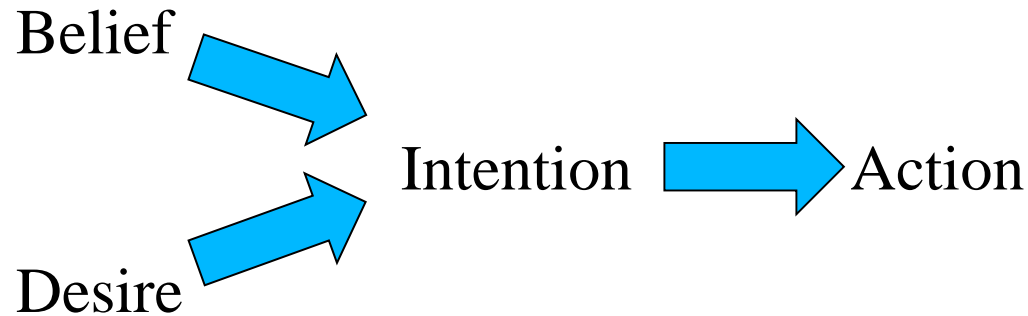
# Action

- ⦿ Chosen to maximize the utility of the actor
- ⦿ **Costly** signalling

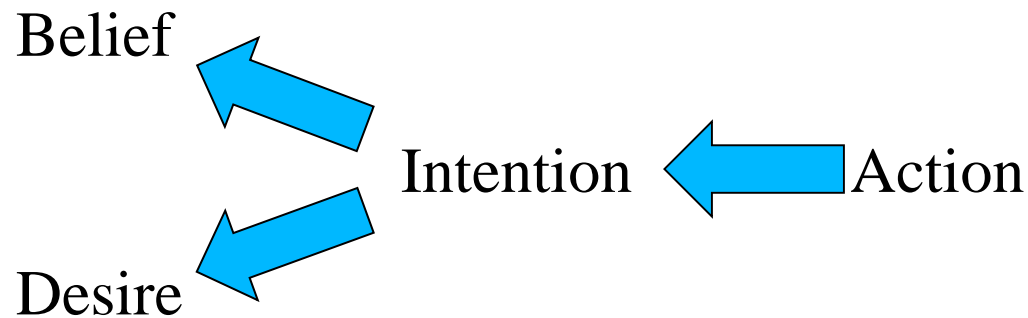


- ⦿ And the informational bankruptcy of “cheap talk”

# The interpretation of action

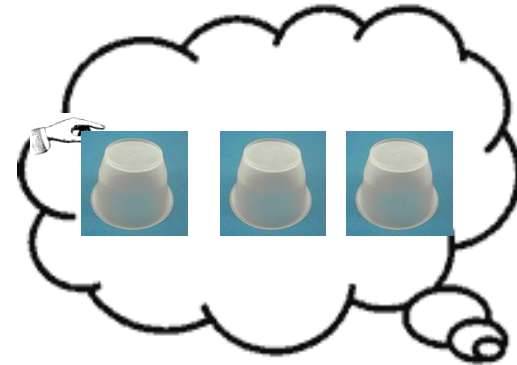


Generation  
of action



Observer's  
inference  
from  
action

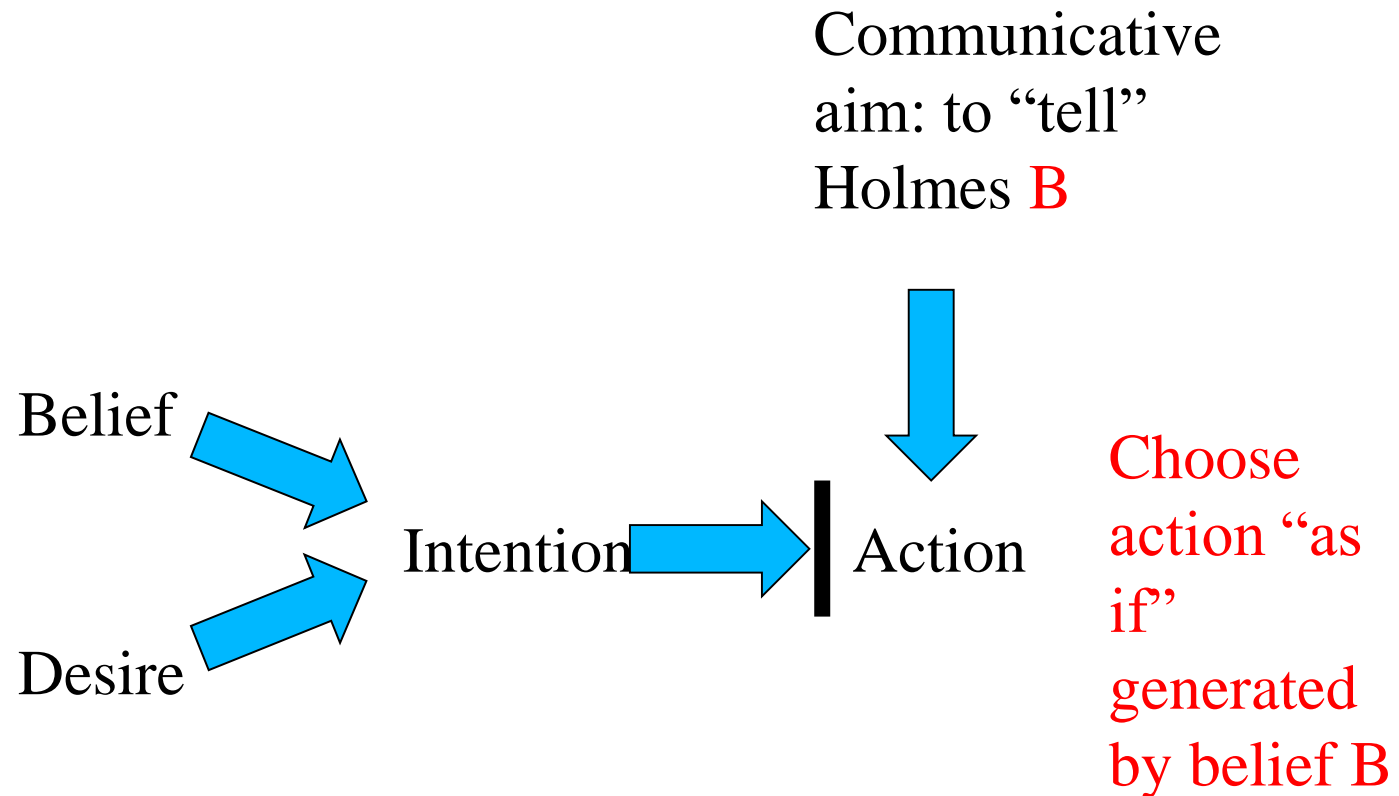
Suppose Watson wants a banana...



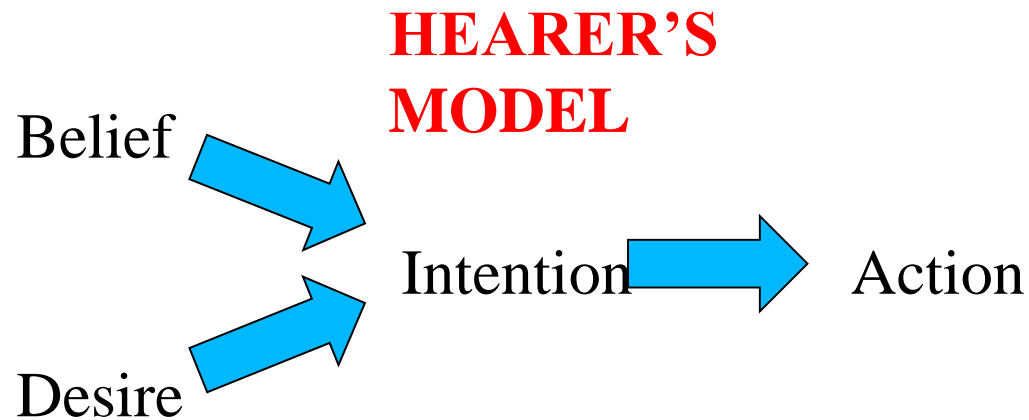
...Holmes infers that Watson believes that the banana is under the left bucket



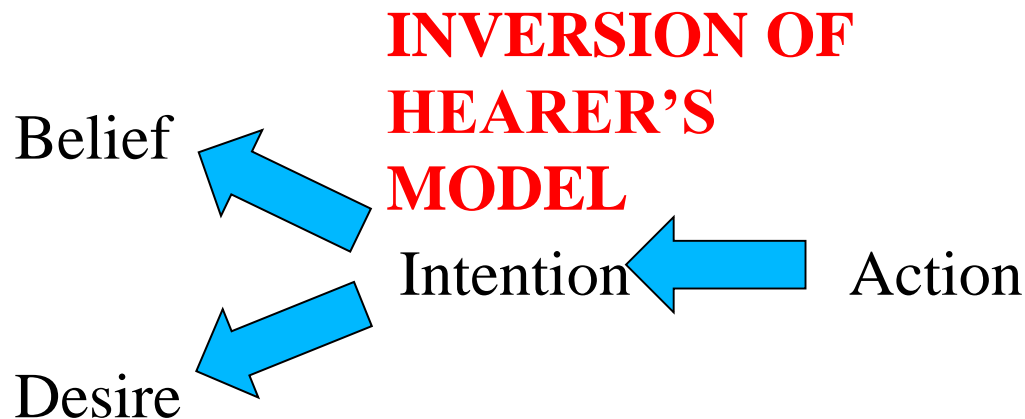
# Hence, actions can be used to convey information, by exploiting this inference



If the hearer does **not** know there is communicative intent, this will work

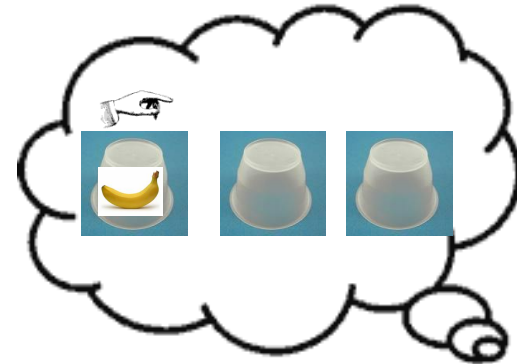


If the hearer does not know there is communicative intent, this will work



Suppose

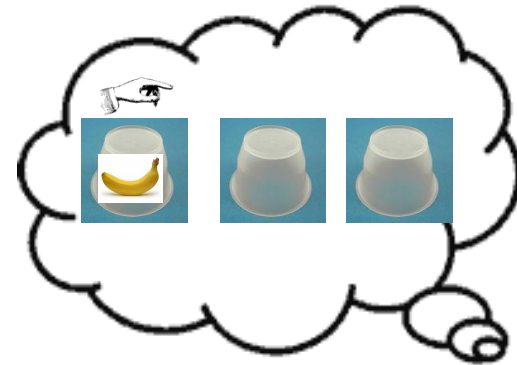
1. Watson does *not* want a banana.
2. But wants Holmes to know where the banana is...



...Holmes infers that Watson believes that the  
banana is under the left bucket  
(if Holmes isn't aware of Watson's intention)

More complicated still!

1. Watson **wants** Holmes to have a belief about where the banana is
2. Holmes **knows** that Watson intends this (and has acted to convey this);
3. But Watson **doesn't** know that Holmes knows...

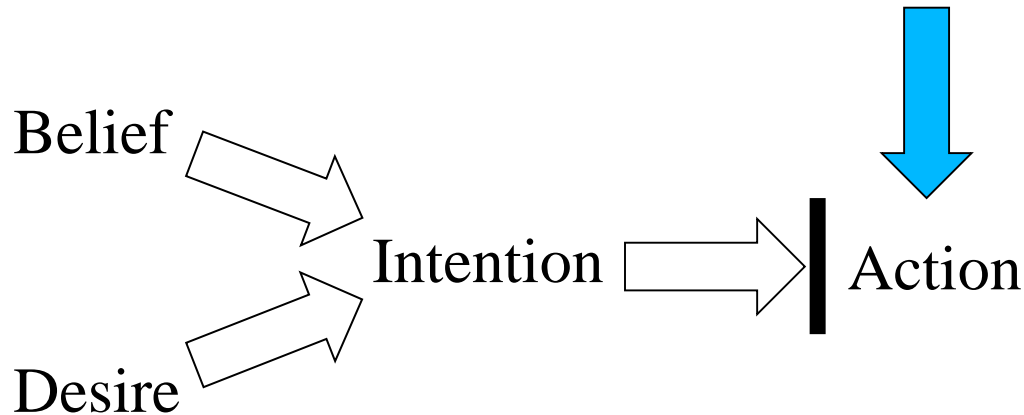


...Holmes infers that Watson wants Holmes to  
have this belief

And we can iterate arbitrarily, but not forever...

# But as soon as the communicative intent is *common knowledge*, the story collapses!

**COMMON KNOWLEDGE** Communicative aim: to “tell” hearer **B**



Because now the belief/desires appear causally irrelevant to the action; cf when a detective sees a clue is *planted*....

# A puzzle

- ⦿ As soon as communicative intent becomes **common knowledge**, the informational ‘link’ between action and belief breaks
- ⦿ ...and we’ll see in a minute just how bad things look, once the link is broken...

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# Communication requires coordinating on a signal-message mapping

- ⦿ Speaker must have interpreted the signal,  $S$ , as conveying message  $M$
- ⦿ Hearer must interpret signal,  $S$ , as conveying message  $M$
- ⦿ So speaker and hearer must “pre-agree” a signal-message mapping
  - But without further communication or we’re in a regress!

# So Holmes and Watson need to interpret the blob in the same way...

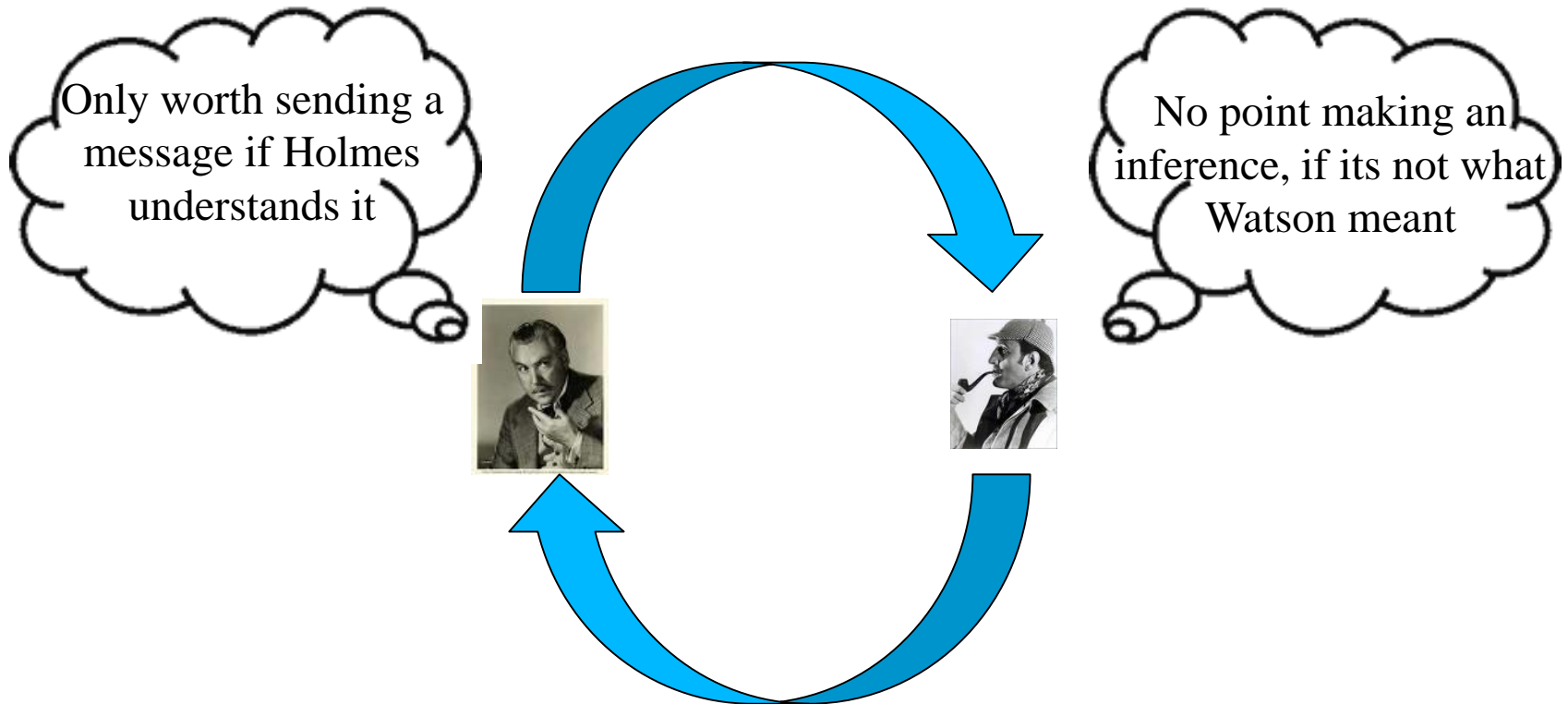


Watson: Place blob  
so that Holmes will  
infer the right thing

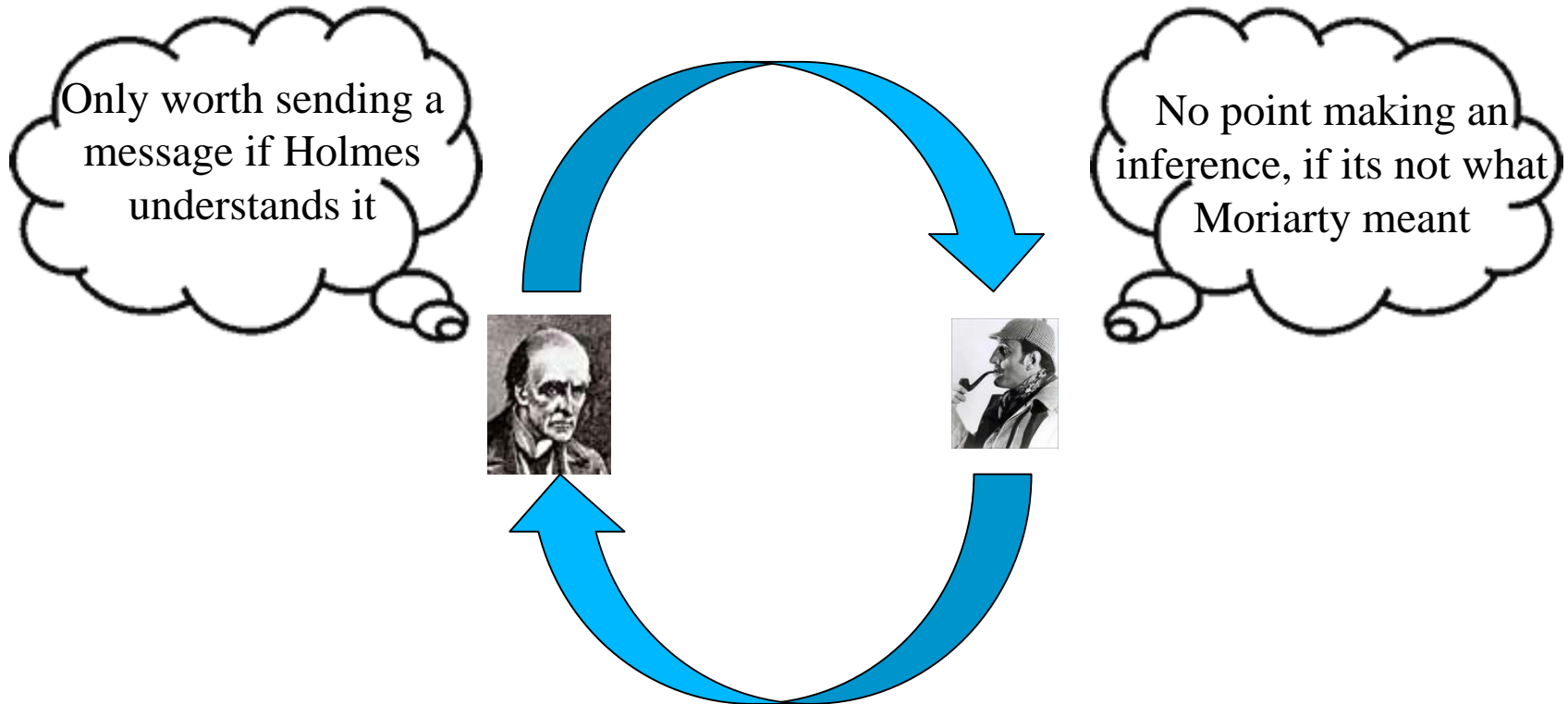


Holmes: Infer  
whatever state would  
have led Watson to  
put the blob here

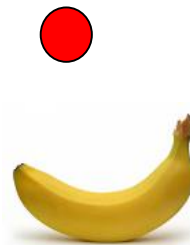
# Communication has “symmetrical” pay-offs



# And communication need not presuppose *cooperation*



# The possibility of communication between enemies







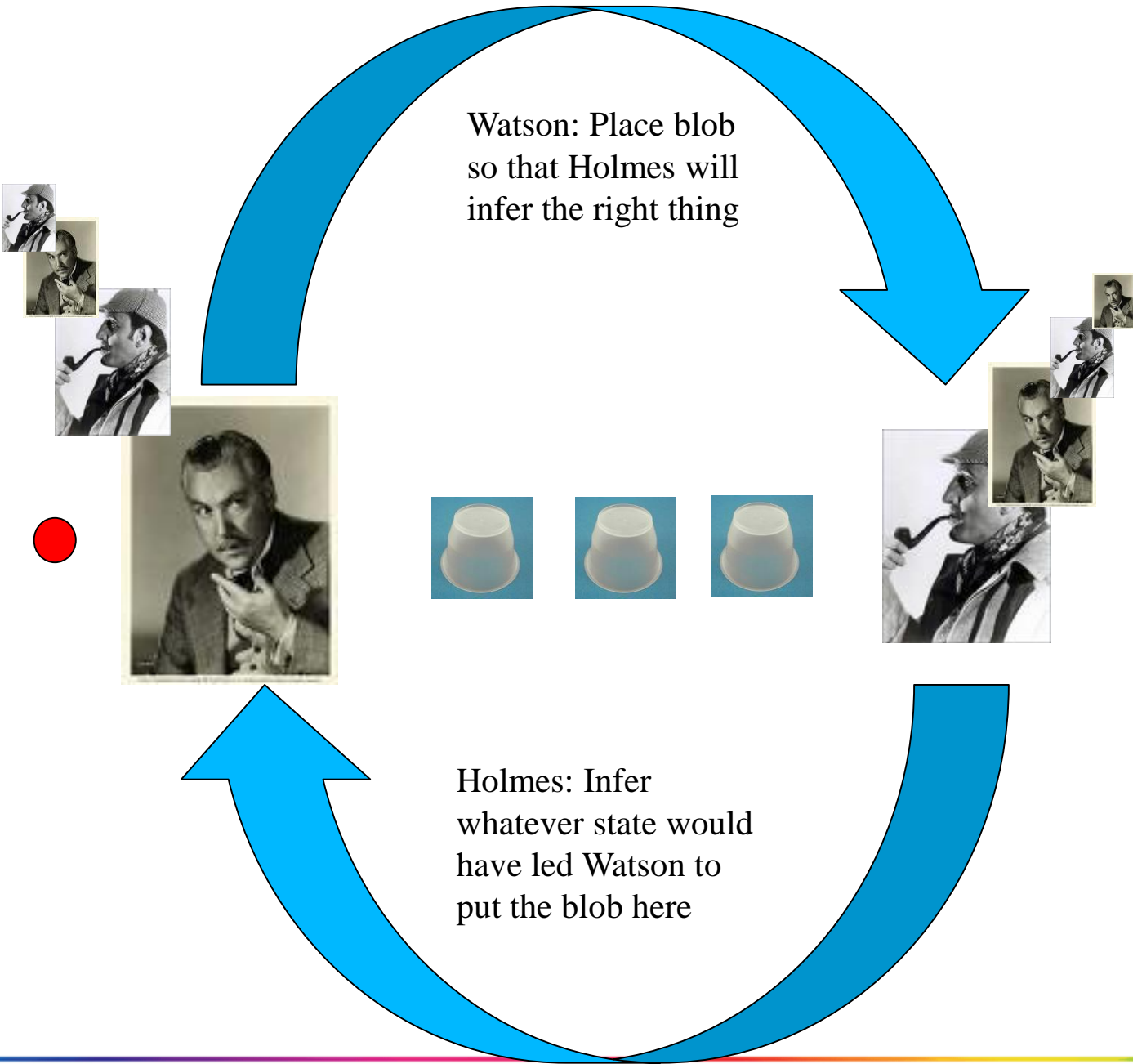


Moriarty means that I should  
take the left bucket...  
But then he could be bluffing...  
Or double bluffing



The **meaning** of ● is common knowledge; but what **information** it conveys is not clear (and may even be nil, if Holmes and Moriarty follow rational choice theory)

- ◎ Signal meaning need not (directly) piggy-back on information (or correlation, or related notions)
- ◎ Meaning may depend on a ‘hypothetical’:
  - If we were cooperating, then we’d agree this*  
(though can we rigorously make sense of this?)
- ◎ Relation to Grice’s cooperative principle?
- ◎ But: how can cooperation possibly work?



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# Coordination in action and communication by virtual bargaining

- ◎ Unification may allow integration of theory of communication and action
  - Solves the infinite regress of mutual prediction
- ◎ The spontaneously communicative convention is that which *we would agree*,
  - given our common knowledge
  - given the hypothetical assumption of cooperativeness
- ◎ Consider the case of action first

# Bargaining over £10

- They are only given three options; no-one gets anything if they don't agree



**X**

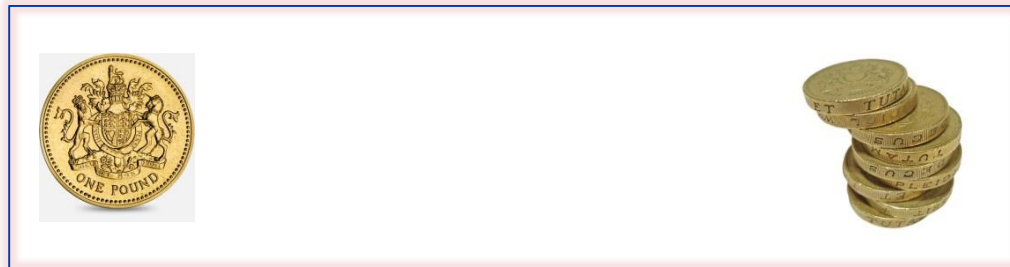


**Y**

# But suppose we can't talk: then **virtually bargaining**



**X**



**Y**

# Virtual bargaining in a nutshell

- ◎ If it is obvious what we would agree, if we could bargain, then we ‘just do it!’ (even if we can talk)
  - The bargain is purely ‘virtual’
- ◎ Seems highly intuitive
- ◎ A theory of rational joint action (But diverges dramatically from standard game theory, Nash equilibrium etc)

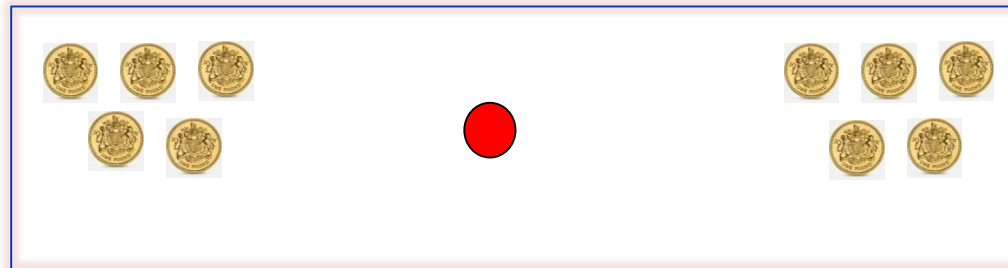


## Communication as virtual bargaining: agreeing (prior to starting the communication interaction) on a signal-message mapping

- ◎ i.e., what is the most communicatively effective mapping that we would prefer?
  - Given the likely signals we'll have to communicate
  - Roles (and hence speech act: command, request, suggestion)
  - Cognitive constraints
  - Common knowledge
  - Past bargains
  - And the relevant payoffs (e.g., how poisonous are the scorpions? How much do we want the money?)

The players hypothetically 'bargain' to choose the best convention (the 'best' may differ between sender and receiver---hence the need for bargaining)

# Suppose Watson is signalling to Holmes...

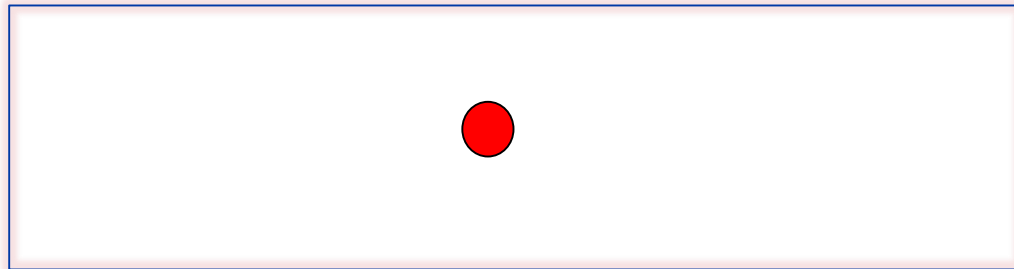


The “best” convention indicates their **virtually agreed** favourite

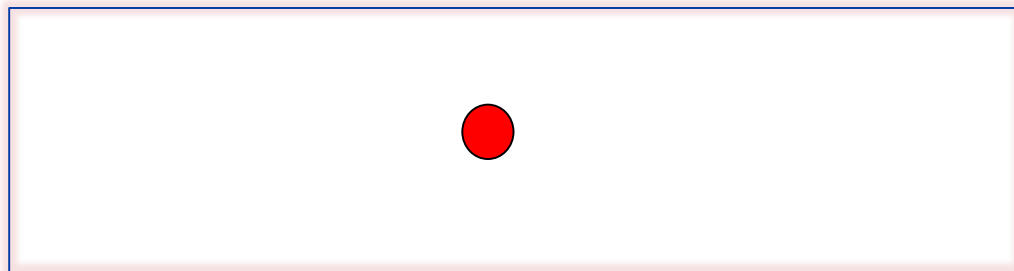
# So an 'honest' sender would signal:



**X**



And a trusting receiver would choose it, expecting to receive the “even” split

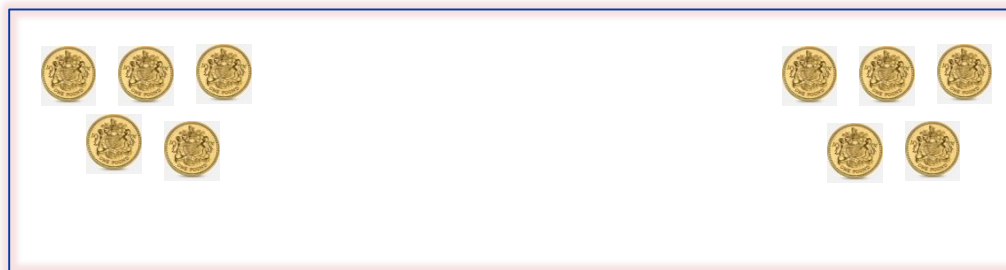
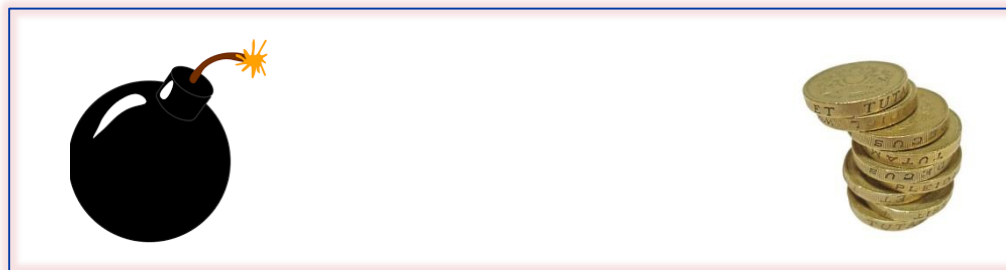
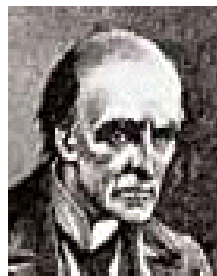


?



Y

# Signals have meaning even when they can't be trusted...



The “best” convention indicates their **virtually agreed** favourite, assuming hypothetical cooperation

# So deception is all too possible

- ◎ Holmes and Moriarty both know what the signal means
- ◎ But neither believes the other will use it honestly
- ◎ So we have the beginnings of a ‘theory of meaning’ which allows the possibility of deception
  - A problem for associative/correlational accounts

# Summary

- ⦿ Communication requires coordinating on a signal-meaning mapping
- ⦿ This coordination can be achieved through virtual bargaining
  - Avoiding infinite regress
- ⦿ Virtual bargaining depends on **common knowledge** and **hypothetical cooperativeness**
- ⦿ This specifies what messages our signals convey, separately from what (if any) trustworthy information theory carry