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An independent academic psychologist, based in England, who has written extensively on different areas of psychology with an emphasis on the critical stance towards traditional ideas.

A complete listing of his writings at <http://kmbpsychology.jottit.com>.

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# **1. MAKING SENSE OF THE WORLD THROUGH ANTHROPOMORPHISM AND OTHER COGNITIVE PROCESSES**

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## **1.1. ANTHROPOMORPHISM**

Anthropomorphism <sup>1</sup> is imbuing the real or imagined behaviour of non-human objects and animals with "human-like capacities and mental experiences" <sup>2</sup>, and it "seems to satisfy the basic motivation to make sense of an otherwise uncertain environment" (Waytz et al 2010b) <sup>3</sup>. Waytz et al (2010b) called this desire to "attain mastery of one's environment", effectance motivation <sup>4</sup>.

Anthropomorphism occurs with some non-human objects more than others (eg: those that look human-like), in some situations and cultures more <sup>5</sup>, and children more than adults. Also individuals lacking social contact (eg: lonely) are more prone to it (appendix 1A). "Anthropomorphism is not an invariant feature of everyday life to be taken for granted but rather a wide-ranging and variable psychological process to be explained" (Waytz et al 2010b p411).

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<sup>1</sup> Xenophanes, over two and a half thousand years ago, used the term. Derived from the Greek - anthropos (human) and morphe (shape or form) (Epley et al 2007). It "involves more than simply attributing life to the non-living (ie: animism). Anthropomorphism involves going beyond behavioural descriptions of imagined or observable actions (eg: the dog is affectionate) to represent an agent's mental or physical characteristics using humanlike descriptors (eg: the dog loves me)" (Epley et al 2007 p865).

<sup>2</sup> For example, Luczak et al (2003) found that a computer hard drive that crashed was imbued with a mind of its own by the majority of respondents.

<sup>3</sup> For example, in the Middle Ages, historical records show that there were over two hundred trials where an animal was the accused (eg: pig for murder in 15th century France). "As rational, educated people, it's easy to smirk at attempts to try animals in a court of law - but one should not be too hasty. After all, the people involved were falling prey to an irrational trait that afflicts us all from time to time: they were anthropomorphising" (Fox 2010 p33).

<sup>4</sup> Epley et al (2007) proposed three factors to explain anthropomorphism in the SEEK model - S = sociality (desire for social connection), E = effectance (motivation for mastery), and Elicited agent Knowledge (accessibility and applicability of anthropomorphic knowledge - eg: perceived similarity between non-human objects and humans).

<sup>5</sup> There are individual differences in anthropomorphism - eg: lack among amygdala-damaged patients (Heberlein and Adolphs 2004), and individuals with autism (Castelli et al 2002).

In terms of the need for control over the environment, Epley et al (2008a) asked participants to explain the behaviour of a dog acting in a predictable way and one acting in an unpredictable way. The latter dog's behaviour was explained with more anthropomorphic traits, but participants with a high need for control described both dogs with more anthropomorphic terms than individuals with a low need for control.

## **1.2. WAYTZ ET AL (2010b)**

Waytz et al (2010b) explored effectance motivation and anthropomorphism with six studies.

### Study 1

This study looked at the relationship between experiencing computer problems and imbuing the computer with its own mind. Two samples of US undergraduates were asked about their computer use in a week (including problems experienced) before answering one of two questions - the computer has a mind of its own or the computer has its own beliefs and desires. Responses were measured by placing an X on a 112 mm-line from "does not appear..." to "definitely appears...".

There was a significant positive correlation between frequency of computer problems experienced and answer to the two questions ( $r = 0.52$  for mind of its own, and  $r = 0.34$  for beliefs and desires). So, individuals who experienced many computer malfunctions (ie: uncontrollable situations) were more anthropomorphic about computers. However, this was only a correlational study (not causation).

### Study 2

Thirty-two US students were asked to rate thirty gadgets, of which half were described in terms that emphasised predictability and half unpredictability. For example, "Clocky-Clocky" was a mobile alarm clock that looked like a furry animal. When the snooze button was pressed, the user could programme it to run away or jump on top of the user (predictable version), versus it would randomly run away or jump on user (unpredictable version). The ratings used seven-point scales that included gadgets having "a mind of its own", "intentions, free will, consciousness", and experiencing emotions. The scales were combined to give an anthropomorphism score.

The participants gave a significantly higher anthropomorphism score to gadgets described in unpredictable language (mean: 2.02) than in predictable

language (mean: 1.69) ( $p = 0.002$ ).

### Study 3

This study aimed to find objective evidence for anthropomorphism by testing participants in a functional magnetic resonance imaging (fMRI) scanner. The twenty-three university participants performed a similar task to Study 2. With anthropomorphic unpredictable gadgets, there was activity in the brain associated with understanding the motives of other humans (eg: ventromedial prefrontal cortex). "These findings suggest that perceiving an agent as having a mind of its own may not be mere metaphor" (Waytz et al 2010b p419).

### Study 4

This study took place at the Museum of Science and Industry in Chicago with fifty-five visitors. Participant asked ten yes-or-no questions of their choice to a robot called "Asimo". The robot either replied with unpredictable or predictable answers. Participants gave more anthropomorphic ratings in the unpredictable condition.

### Study 5

In this study, an incentive was introduced for predicting the behaviour of an unfamiliar robot correctly. Half of sixty-three university students were offered money for correct prediction (motivated condition), and the others simply watched the robot's behaviour (control condition). The robot's behaviour was programmed to be random.

The motivated participants afterwards rated the robot significantly higher on anthropomorphic traits than the control group (mean: 2.20 vs 1.65 out of 7;  $p < 0.035$ ).

### Study 6

If effectance motivation is the basis of anthropomorphism, then individuals who anthropomorphise should feel greater control over their environment. This was tested by Study 6.

Forty-two US students were asked to write a short essay about four objects (a robot, Clocky-Clocky, a dog, and a geometric shape) after watching a short video of them. They were told to anthropomorphise about two of the objects and to write objectively about the other two. Afterwards, the participants rated how well they felt

they understood each object (from 0-10, where 10 = very much). There was a greater perception of understanding for objects where the essay written was anthropomorphic rather than objective.

The researchers felt that these six studies had shown that anthropomorphism arises from effectance motivation. This is the need to feel mastery of an environment, and includes the desire for control, certainty, and no ambiguity.

### 1.3. EGOCENTRISM

When it comes to understanding the attitudes and beliefs of other humans, another process than anthropomorphism is at work - egocentrism. In other words, the own beliefs are used as the basis of other's beliefs (Nickerson 1999). Overimputation of own knowledge/beliefs, however, can be a problem. For example, an individual with left-wing political views assumes that the average person is more left-wing than an individual with right-wing views, and vice versa.

Epley et al (2009) suggested that the same process is involved when understanding the beliefs of god (or gods) on an issue. "Intuiting God's beliefs on important issues may not produce an independent guide, but may instead serve as an echo chamber that reverberates one's own beliefs" (Epley et al 2009 p21533) <sup>6</sup>.

Epley et al (2009) investigated this idea with four surveys (Studies 1-4) in the USA. In Study 1, fifty-four believers in God were recruited at a railway station in Boston. They were asked to respond to six statements about abortion <sup>7</sup>. Then they were asked to rate the statements as they thought God (as they understood God), President George.W.Bush (well-known beliefs) and Bill Gates (unknown beliefs) would respond <sup>8</sup>. An "egocentric correlation" was calculated. That is the closeness of the ratings between the own beliefs and others. The correlation between own beliefs and God's beliefs was +0.59 (ie: closer) than for own beliefs and Bush's (-0.14), and own beliefs and Gates' (-0.02).

Study 2 used the same procedure but focused on

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<sup>6</sup> Xenophanes, in the sixth century BCE, noted that the Greeks saw their gods as fair skinned, whereas images of gods in Africa were dark skinned (Epley et al 2009).

<sup>7</sup> Eg: "I believe that minors (under the age of 18) should be allowed abortions without parental consent".

<sup>8</sup> The order of rating was counter-balanced - ie: sometimes own beliefs asked first and sometimes after others.

attitudes to same-sex marriage <sup>9</sup> with thirty-seven undergraduates in Chicago who believed in God. The participants rated the statements for own beliefs, God, Bush, an average American, and Katie Couric (television personality - unknown beliefs). The correlation of own and God's beliefs was +0.72, and +0.41 for own and average American, but negative correlations for the other two.

Study 3 used Chicago undergraduates again (n = 116), with six moral issues (eg: abortion, legalisation of marijuana). The overall correlation between own beliefs and God's was +0.46, which is significantly higher than the correlations for an average American, Gates or Bush.

Study 4 was administered online in the USA, and included self-rated believers in God (n = 922) and non-believers (n = 77). On the issues of abortion, and same-sex marriage, they gave their opinion, that of an average American, and that of God. For the believers, the correlation between own and God's beliefs was higher than own and an average American. For non-believers, there was no difference in the correlations.

Epley et al's (2009) next study (Study 5) was an experiment. It tested the following prediction: "If believers are especially egocentric when making inferences about God's beliefs, then manipulating believers' own attitudes should similarly manipulate predictions of God's attitudes but should have less consistent impact on predictions of other people's attitudes" (p21535). One hundred and twenty-one individuals in the USA completed the study online. The issue was affirmative action (ie: positive discrimination), and participants read arguments in favour <sup>10</sup> or against (random allocation) before reporting their attitudes, God's, the average American, Gates, and Bush about it. In both conditions, own beliefs correlated strongly with God's on affirmative action, which was higher than the other correlations. But there was no

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<sup>9</sup> Eg: "I believe that same sex couples should be granted the same marriage rights as heterosexual couples".

<sup>10</sup> Argument in favour of affirmative action - "Unfortunately, even people with the best intentions show some automatic biases that they cannot control. [In one study], researchers sent job applications to real companies. There were two groups of applications: applicants in both of the groups were equally qualified. The only way the two groups differed is that one group had applicants with typically 'White names' and one group had applicants with typically 'Black names'. Researchers found that those with typically 'White names' had a 50% greater chance of getting a call-back for an interview than those with typically 'Black names'. Thus, even when qualifications are equivalent, Blacks tend to be at a disadvantage. Affirmative action helps to overcome this disadvantage. Given that these biases are automatic and people with good intentions cannot control them, we need some solutions that ensure decisions are not influenced by the biases. Affirmative action represents one such solution" (Epley et al 2009 supplemental information).



baseline measure of attitudes to know if the own beliefs had changed due to reading the arguments on affirmative action.

Study 6 was an experiment that included a baseline measure of attitudes. Forty-eight believers in God in Chicago were asked about their attitude and God's towards the death penalty. Then the participants were asked to deliver a speech in front of a video camera that was either consistent or inconsistent with their views on the subject. This tends to produce attitude change in the inconsistent condition. Afterwards, the participants were asked about their beliefs on the death penalty, and those of God, Gates, Bush, and an average American. The reported views of God on the subject correlated highest with the own beliefs after the attitude change. In other words, if individuals changed their attitudes on the death penalty, so did their rating of the views of God.

The final study (Study 7) took place in a fMRI scanner with seventeen volunteers. Participants reported their own, God's, and an average American's beliefs on certain topics. Reporting own beliefs and God's beliefs produced similar patterns of brain activity, whereas there were differences in activity for the own versus American's beliefs. Epley et al (2009) stated: "Inferences about God's beliefs appear to egocentrically biased... because the process used to generate inferences about God's beliefs is relatively similar to the process used to generate one's own beliefs" (p21536).

Altogether, the studies showed that "religious believers are particularly likely to use their own beliefs as a guide when reasoning about God's beliefs compared to when reasoning about other people's beliefs" (Epley et al 2009 p21536).

In terms of the implications of the findings, Epley et al (2009) said: "Religious beliefs need not be explained by any unique psychological mechanisms, but instead are likely to be the natural outcome of existing mechanisms that enable people to reason about other social agents more generally. Insights into the basic mechanisms that guide social cognition are therefore likely to be of considerable value for understanding religious experience and belief" (p21537).

#### **1.4. INTENTIONALITY**

Randomness is difficult for humans to understand as they try to make sense of the world. Lottery draws, for instance, are random in terms of which names are drawn, yet individuals still look for patterns in past draws to predict the future as if the draw was not random.

In a classic study by Langer and Roth (1975) (appendix 1B), participants observed a person predicting a coin toss. When the predictor was correct four times in a row, observers believed that the predictor would be right on the fifth occasion because of a skill or ability to control the outcome.

Caruso et al (2010) noted two misunderstandings that occur in such situations:

i) "The hot hand" - The belief that a run of consistent events (a streak) will continue. For example, if a person is correct in three recent guesses about a die, they will be correct again, despite each roll being a statistical independent event.

ii) "The gambler's fallacy" - This is the opposite. The belief that a streak will reverse. For example, a gambler who has lost in the last six bets will win on the seventh.

Though these misunderstandings are opposites, Caruso et al (2010) agreed that there was a common underlying mechanism - perceived intentionality of the agent <sup>11</sup>. "Simply put, we predict that an observed streak will be judged more likely to continue the more people perceive that the agent generating the streak is acting intentionally" (Caruso et al 2010 p149).

Caruso et al (2010) reported four studies to test this prediction. In Study 1, seventy-seven participants watched a video of a person rolling a die with the aim of tossing the number 1. They see the person rolling three 1s in a row <sup>12</sup>, and then on the fourth time the video is stopped as the roll takes place. The participants are asked the likelihood that the number 1 will be rolled on a scale of 1 (not at all likely) to 7 (very likely). This scale measured the dependent variable. The participants were divided into two independent conditions, and given different information before watching the video. Half were told that the player was a professional gambler who could roll the number 1 about 50% of the time (intentional condition) (compared to 17% by chance), and half were told that the die was "loaded" to give the number 1 about 50% of the time (unintentional condition). The independent variable was the perceived intentionality.

The participants in the intentional condition were significantly more likely to predict the fourth roll as a number 1 than in the unintentional condition (mean: 4.27

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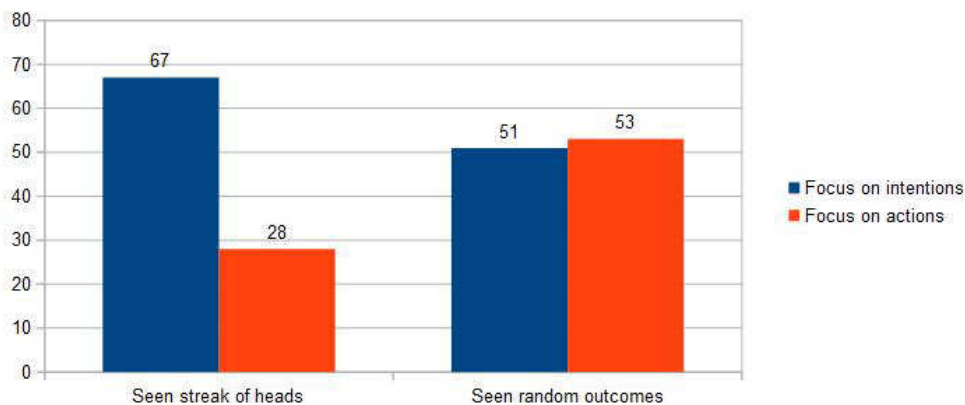
<sup>11</sup> The agent can be a human as in the person guessing at coin toss, or a lottery draw itself.

<sup>12</sup> The participants saw thirteen rolls with the following outcomes - 3, 4, 1, 2, 4, 1, 6, 1, 5, 3, 1, 1, 1.

vs 3.54). Put another way, 39% of the participants in the former condition predicted a number 1 compared to 17% in the latter condition ( $p < 0.05$ ).

Study 2 showed that perceived intentionality influences predictions in situations of streaks only. One hundred and forty-four participants watched a series of coin tosses of a person trying to flip heads. They either saw a streak of four heads or a random mixture of heads and tails before predicting the next toss<sup>13</sup>. The participants were also told to focus on the intentions of the person ("what is he trying to accomplish with his tosses"), or their actions ("the specific movements of his hands and fingers") (control condition). Thus, there were four independent conditions - intention/streak, intention/random, action/streak, and action/random.

There was a significant difference in the prediction of the next toss as a head between the intention/streak condition (67% of participants) and the action/streak condition (28%) ( $p < 0.0001$ ), but no difference between the other two conditions (figure 1.1).



(Data from Caruso et al 2010 table 2 p151)

Figure 1.1 - Percentage of participants predicting the next coin toss would be a head.

Study 3 showed individual differences in "the hot hand" based on focus on intentionality. Twenty-seven participants completed the Behavioural Identification Form (BIF) (Vallacher and Wegner 1989) (table 1.1), which measures how activities are perceived by offering a choice. For example, in the case of locking the front door of a house, a low scorer on the BIF focuses on the actions (putting the key in the lock) involved whereas a high scorer focuses on the intention of the activity (to

<sup>13</sup> This was at the end of 24 coin tosses watched.

secure the house).

Activity	Action focus	Intention focus
Voting	Marking a ballot	Influencing an election
Making a list	Writing things down	Getting organised
Cleaning the house	Vacuuming the floor	Showing one's cleanliness

(Source: Vallacher and Wegner 1989 table 2 p664)

Table 1.1 - Examples of three items from BIF.

After completion of the BIF, participants predicted the likelihood of drawing a spade card from a shuffled pack after three spades in a row. Higher scorers on the BIF were likely to predict another spade card.

These studies have used a human as the intentional agent, even if the situations were random (outside the control of person). Study 4 used a scenario with a non-human object - namely, the stock market. Seventy-seven participants were presented with four graphs showing stock market activity over the past two weeks (upward trend, downward trend, and two graphs with no trend), and asked to predict the following day's stock prices.

Participants also completed the Individual Differences in Anthropomorphism Questionnaire (IDAQ) (Waytz et al 2010a) (appendix 1C). This has fifteen items about attributing intentions and mental states to technological, natural and animal agents (eg: "to what extent does the wind have intentions"). High scorers on the IDAQ were more likely to predict continuing upward or downward trends in stock prices than low scorers. "The more people naturally attribute intentions to non-humans, the more likely they are to predict that observed trends generated by a non-human agent will continue" (Caruso et al 2010 p152).

Caruso et al (2010) concluded: "The ability to recognise another's intentions helps people predict the future and maintain a sense of control over their lives... In fact, perceiving intentionality and perceiving patterns (such as streaks) share a common antecedent in the motivation for control and mastery..." (p153).

## 1.5. APPENDIX 1A - ANTHROPOMORPHISM AND LONELINESS

Epley et al (2008b) stated: "People are motivated to

maintain social connection with others, and those who lack social connection with other humans may try to compensate by creating a sense of human connection with non-human agents" (p114). This is done by anthropomorphism and/or beliefs in "supernatural agents".

Epley et al (2008b) showed these processes in three studies. In Study 1, twenty volunteers completed an online survey about four technological gadgets (eg: "Pillow Mate" - a pillow that can be programmed to give a "hug"). The questions about the gadgets including their attractiveness as well as anthropomorphic items. There were also three questions about loneliness (eg: "How often do you feel isolated from others?"). The anthropomorphic ratings were significantly positively correlated with the loneliness ratings ( $r = 0.53$ ;  $p = 0.02$ ). This was a correlational study, and so causation was not established. The next two studies were experiments which can do that.

Study 2 manipulated the feelings of social connectedness of ninety-nine University of Chicago students before completing a questionnaire about their beliefs on six "supernatural agents" (ghosts, angels, the Devil, miracles, curses, and God). Social connectedness was varied by giving the participants fake feedback from a personality test, which included sentences like, "You're the type who will end up alone later in life" (disconnected condition), or "You're the type who has rewarding relationships throughout life" (connected condition). Half the participants were self-rated believers in God and half not.

Participants in the disconnected condition had a significantly stronger belief in supernatural agents than those in the connected condition (irrelevant of religious belief or not) (mean: 4.35 vs 3.71 out of 10). "Social disconnection does not turn atheists into fundamentalists, of course, but it may nudge religious belief in the same direction for believers and non-believers alike" (Epley et al 2008b p116).

Study 3 used fifty-seven Harvard university undergraduates in a similar experiment. The mood of the participants was manipulated by showing a short film before completion of a questionnaire. The films induced either loneliness or fear, and there was a control clip. The questionnaire asked about beliefs in supernatural agents, and to choose from fourteen traits to describe a pet owned or known well.

Participants in the loneliness (or social disconnected) condition reported stronger beliefs in supernatural agents, and were more likely to choose anthropomorphic traits to describe the pet than the other two conditions.

Epley et al (2008b) interpreted the findings thus: "Lonely people cannot make themselves a world, of course, but they can make themselves a mindful gadget, a thoughtful pet, or a god to populate that world" (p119).

A key element of the two experiments was the manipulation of feelings of social connectedness. There are ethical issues with such research. The researchers do not detail any debriefing after the experiment, but it is assumed that they told the participants in Study 2, for example, that the personality test profile was fake. Great value is placed on personality tests in modern society, and some individuals may believe the results were true despite being told otherwise later. Furthermore, can an experimenter be subsequently believed if they have already given false information?

#### **1.6. APPENDIX 1B - LANGER AND ROTH (1975)**

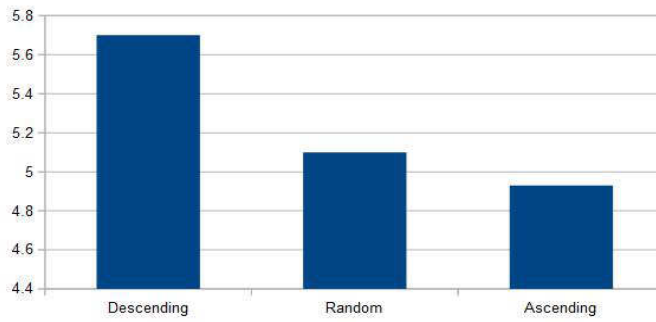
Ninety psychology undergraduates at Yale University in the USA were asked to toss a coin thirty times and predict the outcome in each case. They could not see the coin's outcome, but were told by the experimenter (who was following one of three feedback patterns). All feedback was fifteen correct and fifteen wrong presented as seven of first eight correct and then randomly (descending pattern), seven of last eight tosses correct (ascending pattern), or randomly throughout. The participants also watched another player.

After the coin tosses, the participants rated their ability and the other player's at predicting the outcome. Participants in the descending condition perceived their ability to predict the outcome significantly higher than the other two conditions, and believed that they were correct more often. When asked to predict their success if they did one hundred more coin tosses, participants in the descending condition gave higher scores, and also perceived that they would get better with practice.

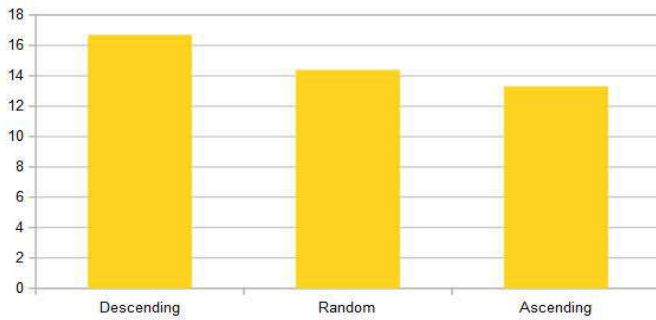
They also rated themselves significantly better than the other player (even when both had the same feedback pattern) (figure 1.2).

Langer and Roth (1975) explained the findings thus: "Apparently a skill attribution is determined early in a sequence of outcomes. After the attribution is made, outcomes inconsistent with it are not given much weight. An early, fairly consistent pattern of successes leads to a skill attribution, which in turn leads subjects to expect future success" (p954).

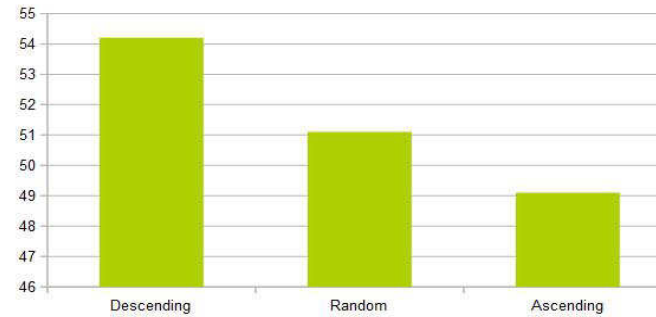
(a) How good do you think you are at predicting outcomes like these?  
(out of 10, where 10 = pretty good)



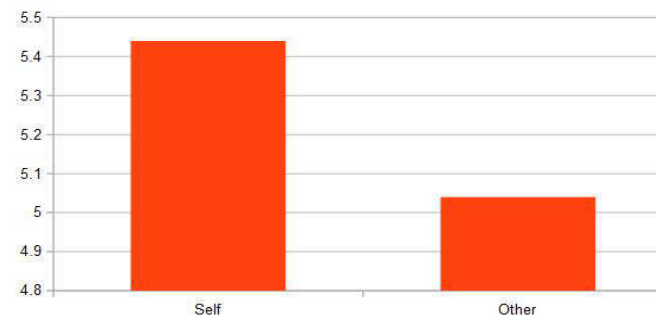
(b) How many guesses did you get correct? (out of 30)



(c) How many guesses would be correct in another 100 trials?



(d) How good do you think you are at predicting outcomes like these? (Self vs other player)



(Data from Langer and Roth 1975 tables 1 and 2 p953)

Figure 1.2 - Mean scores on different questions.

## 1.7. APPENDIX 1C - INDIVIDUAL DIFFERENCES IN ANTHROPOMORPHISM QUESTIONNAIRE (IDAQ)

The measurement of anthropomorphism has varied in studies. The most common way is direct assessment by asking how much a non-human object has human characteristics. Indirect measures use memory mistakes when recalling non-human objects behaving in human-like ways (eg: Barrett and Keil 1996).

Waytz et al (2010a) developed the IDAQ from thirty items given to 348 University of Chicago students (Study 1). Fifteen items (table 1.2) were found to discriminate between high and low overall scorers, and these became the IDAQ. The fifteen items were then tested on 609 individuals from the US general population (Study 2). Test-retest reliability was established by asking the original student sample from Study 1 to complete the IDAQ again 12-19 weeks after the first occasion (Study 3).

The validity of the IDAQ was shown by asking forty University of Chicago students to rate a kitten playing or a snake fighting on emotions perceived to be uniquely human (eg: nostalgia, embarrassment, resentment, hope). High IDAQ scorers gave higher ratings of these emotions to the animals (Study 4).

- To what extent does the average fish have free will?
- To what extent does the average robot have consciousness?
- To what extent do cows have intentions?
  
- To what extent is the average dog good-looking? (not in final 15 items)

All items rated from 0 (not at all) to 10 (very much).

(Source: Waytz et al 2010a appendix p229)

Table 1.2 - Example of items from IDAQ.

Waytz et al (2010a) outlined three major consequences of anthropomorphism:

i) If an agent/object is perceived as capable of conscious experience, then it should receive care and concern.

Waytz et al (2010a - Study 5) asked fifty visitors to the Museum of Science and Industry in Chicago to complete the IDAQ and judge five moral dilemmas. One of the dilemmas involved the morality of destroying IBM's supercomputer called "Deep Blue" that beat a chess grandmaster. The participants rated the dilemmas from "absolutely morally wrong" (-3) to "absolutely morally



right" (+3). The score on the IDAQ predicted judgment of the moral dilemmas. In other words, high anthropomorphising individuals (IDAQ high score) saw destroying "Deep Blue" as morally wrong, for example.

In their Study 6, Waytz et al (2010a) found an association between IDAQ score and concern for the environment (based on anthropomorphising of nature) among fifty-two adults completing an online survey.

ii) If an agent/object is perceived as capable of intentional action, then it is responsible for its actions.

Waytz et al (2010a - Study 7) presented fifty-four adults with scenarios involving trusting a human or a computer to make an important decision (eg: predict heart attacks; select candidates to admit to university). High IDAQ scorers showed greater trust in computer decisions than low scorers.

iii) If an agent/object is perceived as having a mind of its own, then it is capable of evaluating the observer, and the observer will thus follow social norm.

Among thirty-eight participants, Waytz et al (2010a - Study 8) showed a positive correlation between IDAQ score and Marlowe-Crowne Scale of socially desirable responding (Crowne and Marlowe 1964)<sup>14</sup> when the latter was administered by an anthropomorphised robot.

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<sup>14</sup> Eg: "Have there been occasions when you have taken advantage of someone?" (yes/no).

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## **2. UNUSUAL ANIMAL BEHAVIOURS AND PREDICTING EARTHQUAKES**

Earthquakes are difficult to predict in terms of when (time), where (location), and how large (magnitude). Unusual animal behaviours (UABs) have been reported before large earthquakes, and so there is a question of whether these could help in predicting earthquakes.

Small animals and insects seem to show UABs first <sup>15</sup>, and then larger animals (Yamauchi et al 2014). There are numerous reports of pets showing UABs up to 24 hours prior to the event. Dogs barking loudly, or biting their owners, for example, and cats hiding or disappearing (Ikeya 2004) <sup>16</sup>. These animals can hear ultrasounds (while humans cannot) and have more sensitive smell than humans. So they may be responding to sounds or smells pre-earthquake (Yamauchi et al 2014).

Yamauchi et al (2014) collected data on the UABs of pets prior to a large earthquake off the Pacific coast of Tohoku, Japan on 11th March 2011. Information was collected via a web survey nine months after the event. Owners were asked to rate their dogs and cats for sixteen behaviours (eg: escaped, barked more than usual, hiding) for six periods before the earthquake ("from a few seconds to minutes" to "six or more days").

There were 1962 usable responses (1259 from dog owners and 703 cat owners), and the distance to epicentre was calculated in each case. Around one-fifth of pet owners reported UABs by their pets, with restless behaviour being most common. The majority of UABs were a short time before the earthquake (within one day) (figure 2.1).

But there was a foreshock on 9th March 2011, and the behaviour of the pets could have been a stress response to this event rather than prediction of the 11th March one <sup>17</sup>. Yamauchi et al (2014) discounted this as the full explanation for the UABs. Also the survey was retrospective with the possibility that the pet owners interpreted certain behaviours as predictive after the event.

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<sup>15</sup> Based on three years of constant monitoring, changes in the behaviour of red wood ants hours before an earthquake have been observed in two mounds in west Germany. The ants have a standardised cycle of behaviour, and prior to an earthquake, the nocturnal rest period and daily activity were suppressed (Berberich et al 2013).

<sup>16</sup> For example, all these behaviours were reported in a questionnaire given to 1200 residents after the L'Aquila earthquake in Italy in 2009 (Fidani 2013).

<sup>17</sup> Fidani (2013) noted that pets may show anomalous behaviour for a time after the earthquake, and owners may find it hard to distinguish whether the UABs appeared before and after the event.

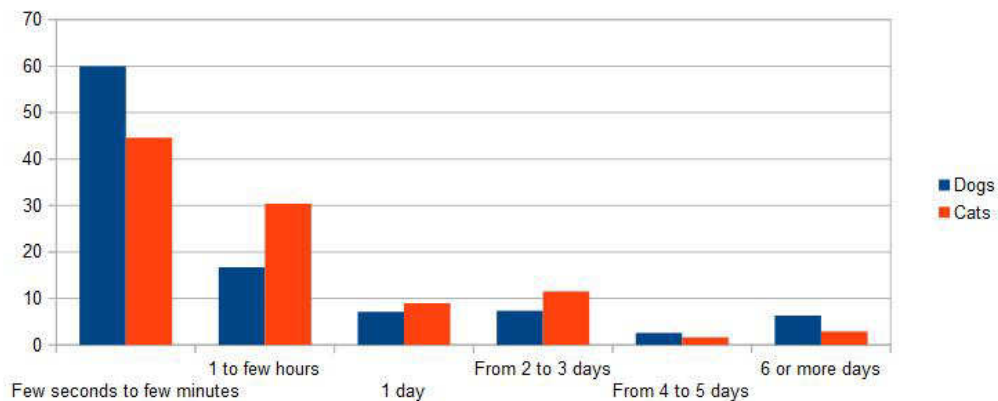


Figure 2.1 - UABs based on time before earthquake (%).

One phenomenon prior to earthquakes that may be causing the UABs is ultra-low frequency (ULF) electromagnetic waves. These cause itchiness and/or anxious behaviour in at least thirty-five species studied experimentally (Ikeya and Whitehead 2013). There have been reports that ULF waves disrupt the circadian rhythms and sleep patterns of mice (Yokoi et al 2003), and the hibernation patterns of snakes and stage beetles (Ikeya 2004).

But what about humans? For example, after the Kobe earthquake in Japan (5.47 am on 17th January 1995) many survivors reported having woken unusually early (5 am) (Ikeya 2004).

Ikeya and Whitehead (2013) collected waking data in relation to this earthquake focusing on children. Two samples were used - 8-10 year-olds soon after the event, and university students ten years later. Two questions were asked about time of waking on 17th January 1995 and location. Around 1100 individuals were questioned.

One hundred and sixty-eight of them (15%) reported waking around one minute or more before the earthquake. The authors admitted that it was "rather hard to imagine this sensitivity shown by children to be very useful for practical earthquake prediction. Only a minority of children displayed it" (Ikeya and Whitehead 2013 p234).

Parents at an early childhood centre in Christchurch, New Zealand had reported an increase in children not sleeping, waking often in the night, and being clingy in the day or two prior to the September 2010 earthquake there (Whitehead and Ulusoy 2013).

Grant and Conlan (2013) noted that with "short-term earthquake risk forecasting, the avoidance of false alarms is of utmost importance to preclude the possibility of unnecessary panic among populations in seismic hazard areas" (p962). For example, large

migrations of amphibians (eg: "frog swarms") have been reported in the media as signs of upcoming earthquakes, leading to fear in certain high seismic risk areas (eg: Thessaloniki, Greece, May 2010; Moratuwa, Sri Lanka, May 2010; Wuhan, China, 2011) (Grant and Conlan 2013).

Grant and Conlan (2013) found that only two of 28 media reports of such swarms since 1850 actually preceded large earthquakes<sup>18</sup>. News reports of frog or toad swarms between 1850 and 2010 were collected along with information about earthquakes in the following month. The majority of cases were normal migrations of juvenile frogs and toads from their breeding ponds in a year when the numbers born were high. The authors warned: "Reports of suspected unusual animal behaviour in seismic hazard locations should be interpreted with caution, and consultation with experts in the field of earthquake biology is advised to avoid false alarms. When using media and anecdotal reports, awareness of possible reporting and recollection bias should be maintained" (p975).

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<sup>18</sup> Grant and Conlan (2013) pointed out: "There is likely to be a bias in reporting frog swarms in seismic risk zones. The media in earthquake risk areas are inherently interested in frog swarms because of mythology which links them to earthquakes" (p972).