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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. EVOLUTIONARY ARMS RACE - BATS, MOTHS AND ECHOLOCATION

1.1. BATS AND ECHOLOCATION

Predators can listen for their prey passively or actively. The former is waiting for noises made by the prey (eg: owl waits for noise of movement made by prey; figure 1.1), while active listening involves echolocation ("biosonar") (table 1.1). Bats (Order: Chiroptera) make use of this technique, which evolved over 65 million years ago [1], and involves projecting sounds (usually ultrasonic [2]) into the environment and using their echo to "'see' using sound" (Conner 2013) (figure 1.2) [3] [4]. It is mainly used to orient the bat in space (ie: relative position in environment), and for hunting (flying) insects (detection, identification and localisation) (Schnitzler and Kalko 2001).

(Drawing by Magda Královenská)

Figure 1.1 - An owl capturing prey.

ADVANTAGES	DISADVANTAGES
1. Able to hunt at night and when vision limited.	1. Prey can hear predator approaching.
2. Useful over long distances.	2. Depends on success of accurately hearing echo.

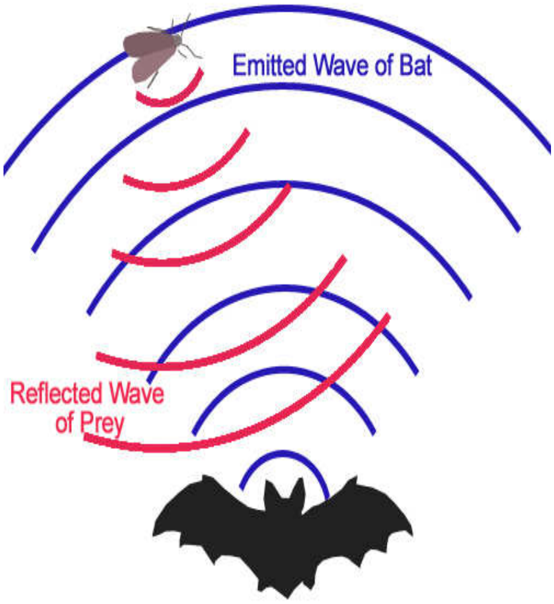
Table 1.1 - Main advantages and disadvantages of using echolocation to hunt.

[1] Echolocation is primarily used by bats of suborder Microchiroptera (nearly 700 species; Miller and Surlykke 2001), and less efficiently by some species of the suborder Megachiroptera (Schnitzler and Kalko 2001).

[2] The frequency between 8 - 215 kHz and 3 - 200 times per second (pulse repetition rate) depending on the species of bat (Conner and Corcoran 2012).

[3] The bats listen for the presence, delay, and harmonic structure of the echoes of the ultrasonic pulses.

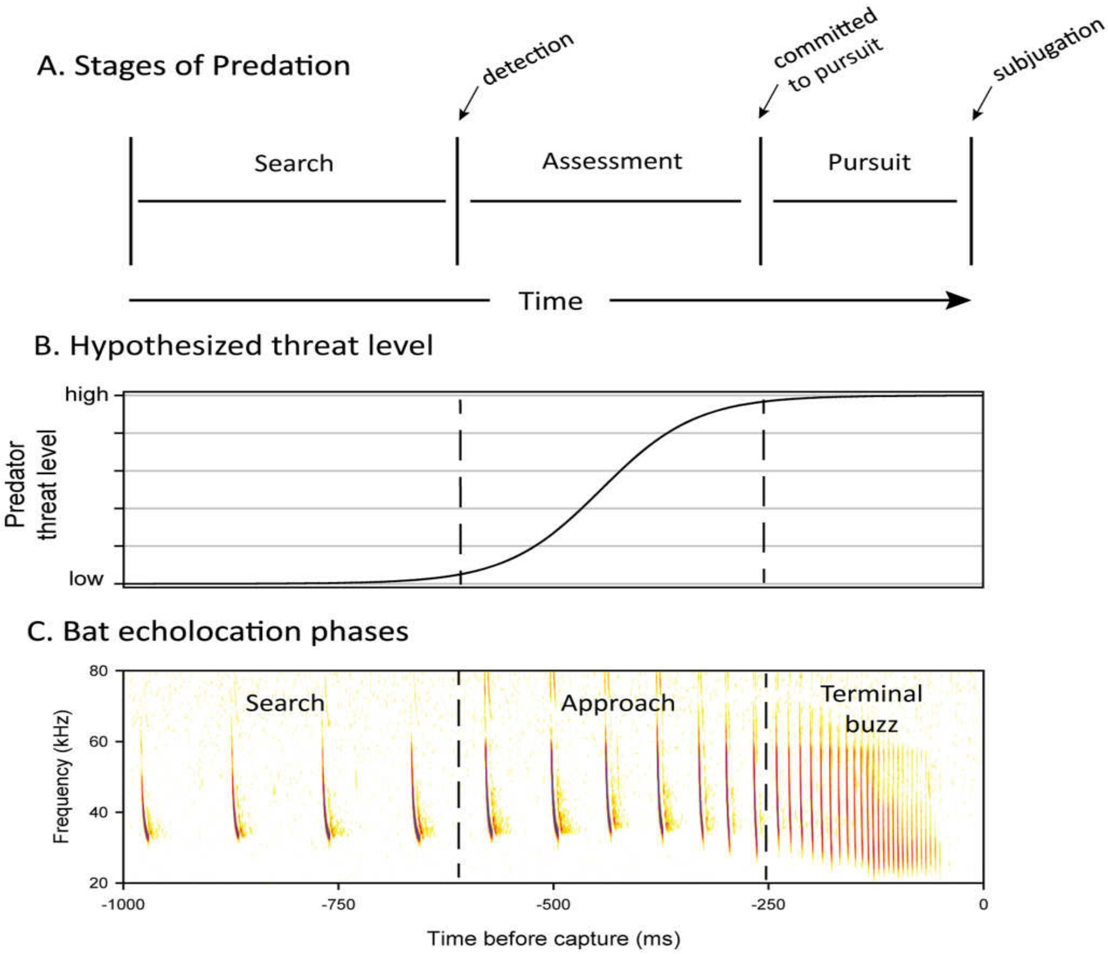
[4] Some bats use passive hearing as well as echolocation, others do not (Schnitzler and Kalko 2001).



Hunting with echolocation has three elements - detection (receive echo information), classification (ie: echo is prey), and localisation (where is prey exactly). A general pattern would be low repetition at 3 - 15 kHz for long durations (5 - 30 ms) when searching, increased repetition when prey detected, and terminal (buzz) (capture) of short pulses (0.5 - 1 ms) at high frequency (100 - 200 kHz) (Conner and Corcoran 2012) (figure 1.3).

(Source: Shung; in public domain)

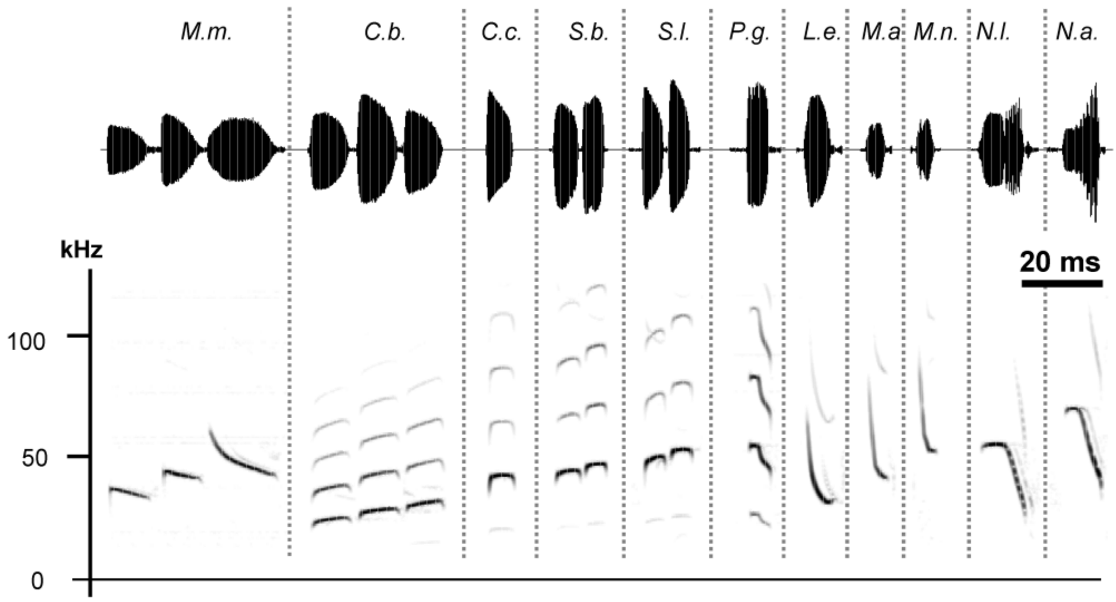
Figure 1.2 - Echolocation.



(Source: Corcoran et al 2013 figure)

Figure 1.3 - Stages of hunting by bats.

Different species of bat have their own frequency structure, duration, and sound pressure level of echolocation (figure 1.4). There are different signals when searching for prey, and when approaching them. Hunting involves the capture of moving prey in flight (aerial mode) or stationary on vegetation or the ground (gleaning mode) or on water (trawling mode). Hunting also takes places in open environments, near the edges of vegetation, inbetween vegetation or dense forests, or near the ground. Different species of bats have evolved in specific environments (table 1.2) (Schnitzler and Kalko 2001).



(Time-signals and spectrograms of search phase echolocation calls of the 11 bat species. Dashed vertical lines separate species. The 20 ms time scale applies to both time signals and spectrograms, but pulse intervals between calls are collapsed. Calls from species emitting more than one call type were consecutive calls from one recording. Molossus molossus (M. m.) is an open air forager. Cormura brevirostris (C. b.), Centronycteris centralis (C. c.), Saccopteryx bilineata (S. b.), S. leptura (S. l.), Pteronotus gymnonotus (P. g.), Lasiurus ega (L. e.), Myotis albescens (M. a.), and M. nigricans (M. n.) are edge-space foragers. Noctilio leporinus (N. l.) and N. albiventris (N. a.) are trawling bats)

(Source: Surlykke and Kalko 2008 figure 1)

Figure 1.4 - Different echolocation calls.

Echolocation has certain characteristics and issues to deal with (Conner 2013):

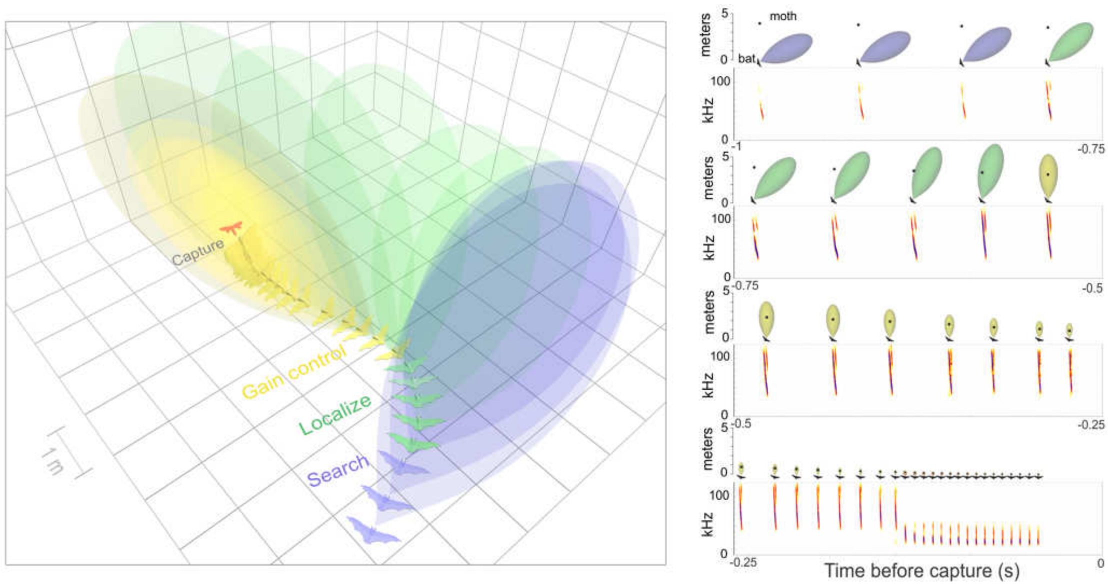
i) The wavelength of the signal produced - Shorter is better to detect small items. This is important when

ENVIRONMENT	FORAGING MODE	SPECIES EXAMPLE	TASK/STRATEGY
Uncluttered space	Aerial	Free-tailed bats	Finding small prey sparse distributed in large area - long narrowband signals
Background-cluttered space (eg: forest edges)	Aerial Trawling	Evening bats	Distinguish weak echo of insects from clutter - mixed signals
Highly cluttered space (eg: close to ground or vegetation)	Aerial	Horseshoe bats	Avoid collisions - long duration (10 - 100 ms) medium to high frequency signals
Highly cluttered space (eg: close to ground or vegetation)	Trawling	Slit-faced bats	Exact spatial position of prey - short duration signals (1 - 3 ms)

Table 1.2 - Different environments and different types of echolocation.

the bats' prey is tiny (eg: mosquito, beetle, or moth) [5].

ii) The beam of the emitted signal - Narrowly focused beams are more accurate at target detection, while wider beams allow a wide scan of the area. Jakobsen et al (2012) reported that bats can vary the beam. A narrower beam is produced by opening the mouth wide and increasing call frequency, and a wider beam by closing the mouth and reducing the call frequency (figure 1.5).



(Source: Corcoran et al 2013 figure 2)

Figure 1.5 - Three-dimensional simulation of the sonar beam of a bat attacking a moth (left panel), and a spectrogram of the bat echolocation sequence with two-dimensional plots of the bat's echolocation beam shape and direction relative to the target (right panel).

[5] Schnitzler and Kalko (2001) calculated that a 2.5 cm insect can be accurately detected at 10 metres.

iii) The frequency of the signal - For example, some bats can sweep from high to low frequency (called frequency modulating or FM bats) (eg Little brown bat; Myotis lucifugus; figure 1.6) for crowded environments (eg: prey flying between branches). Other bats (called constant frequency or CF bats) (eg: Lesser horseshoe bat; Rhinolophus hipposideros; figure 1.7) produce signals of the same frequency, and moving prey can be detected by the Doppler shift [6]. The echo from prey moving towards the bat increases in frequency. Some bats can use both methods (eg: Indian pygmy pipistrelle; Pipistrellus mimus) (Conner 2013).

(Source: Moriarty Marvin, US Fish and Wildlife Service; in public domain)

Figure 1.6 - Little brown bat.

[6] Schnitzler and Kalko (2001) found that the Mustached bat (Pteronotus) (using CF) is able to detect the movement of the fluttering wings of the prey such as to determine the type of prey.

(Source: F C Robiller/naturlichter.de)

Figure 1.7 - Lesser horseshoe bat.

iv) Sound localisation - The information coming into the ears depends on the azimuth (horizontal angle in relation to the direction the listener is facing) and the elevation of sound. The time of arrival at each ear is also important.

v) Dealing with clutter (or clutter echoes) - This is the echo from non-targets. Some bats send out sounds in pairs (called "strobe groups") of which each one has a slightly different frequency. This allows the bat to keep track of the incoming echoes more efficiently and reduce the effect of clutter (Conner 2013).

1.2. EVOLUTIONARY ARMS RACE

Predator and prey are locked in an "evolutionary arms race" (or co-evolution) (Dawkins and Krebs 1979). Any method used by a predator will be combated eventually by prey who have evolved a "counter-measure", and then subsequently the predator evolves a way around this and so on (figure 1.8) [7] [8]. Moths (figure 1.9) have evolved

[7] There is "a kind of evolutionary escalation going on between bats and insects" (Miller and Surlykke 2001).

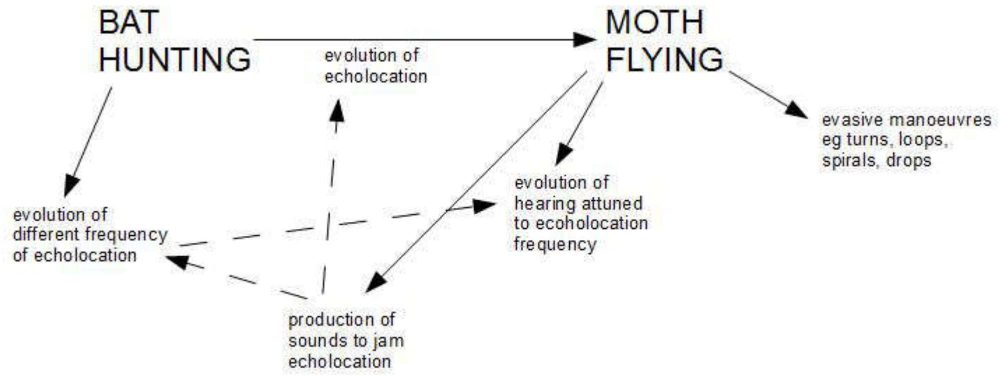


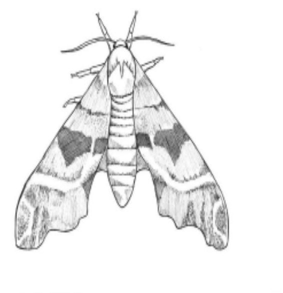
Figure 1.8 - "Evolutionary arms race".

techniques to combat the echolocation of bats. These techniques include (Conner 2013):

a) "Auditory camouflage" - For example, moths that cluster close to vegetation will become "invisible" because of clutter.

b) Reducing the echo - Zeng et al (2011) suggested that the scales on moths' wings are able to absorb the incoming sound of the bats' cries and thus reduce the echo.

c) Jamming - This is interfering with the reception of the echoes by producing sounds. For example, tiger moths (Bertholdia trigona) can produce a "cacophony of clicks" [9] (made by tymbal organs on the thorax) aimed at the bats (Corcoran et al 2009) [10] [11].



(Drawing by Magda Královenská)

Figure 1.9 - A moth.

[8] For example, bigger moths are easier to detect (ie: from further away - eg: 10 m), but these moths may be more sensitive to bat echolocation (eg: from 100 m away) - a "ten-fold margin of safety" (Miller and Surlykke 2001).

[9] High-duty-cycle clicks (ie: fast repetition).

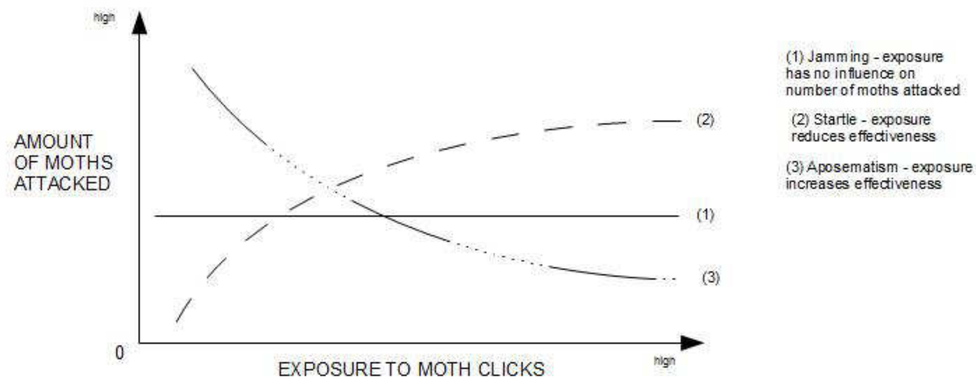
[10] Three juvenile (naive) and one adult bat were tested on nine successive nights. On nights 1-7 the moths clicked, and nights 8-9 they were rendered unable to click. The bats were allowed one minute or five approaches to the tethered moths. The control condition used a palatable wax moth. The mean number of captures was 19% when the moths clicked compared to 93% in the control condition.

[11] No prior learning was needed by the bats nor habituation occurred, and both juveniles and the adult were affected by the jamming.

If the clicks are similar to the echoes, the bats will misperceive the object (phantom echo hypothesis), or the clicks could mask the echoes (like "white noise") (eg: 4500 clicks per second) (masking hypothesis), or the clicks reduce the accuracy of locating the prey (ranging inference hypothesis [12]) (Conner and Corcoran 2012).

Corcoran et al (2011) tested the different hypotheses with tiger moths and naive big brown bats in the laboratory [13]. If the phantom echo hypothesis was correct, the bats would attack a "phantom" away from the moth. If the clicks interfered, the bats would miss the target by a small amount, and the masking hypothesis predicted that the bats would lose track of the target altogether. The results confirmed the ranging inference hypothesis.

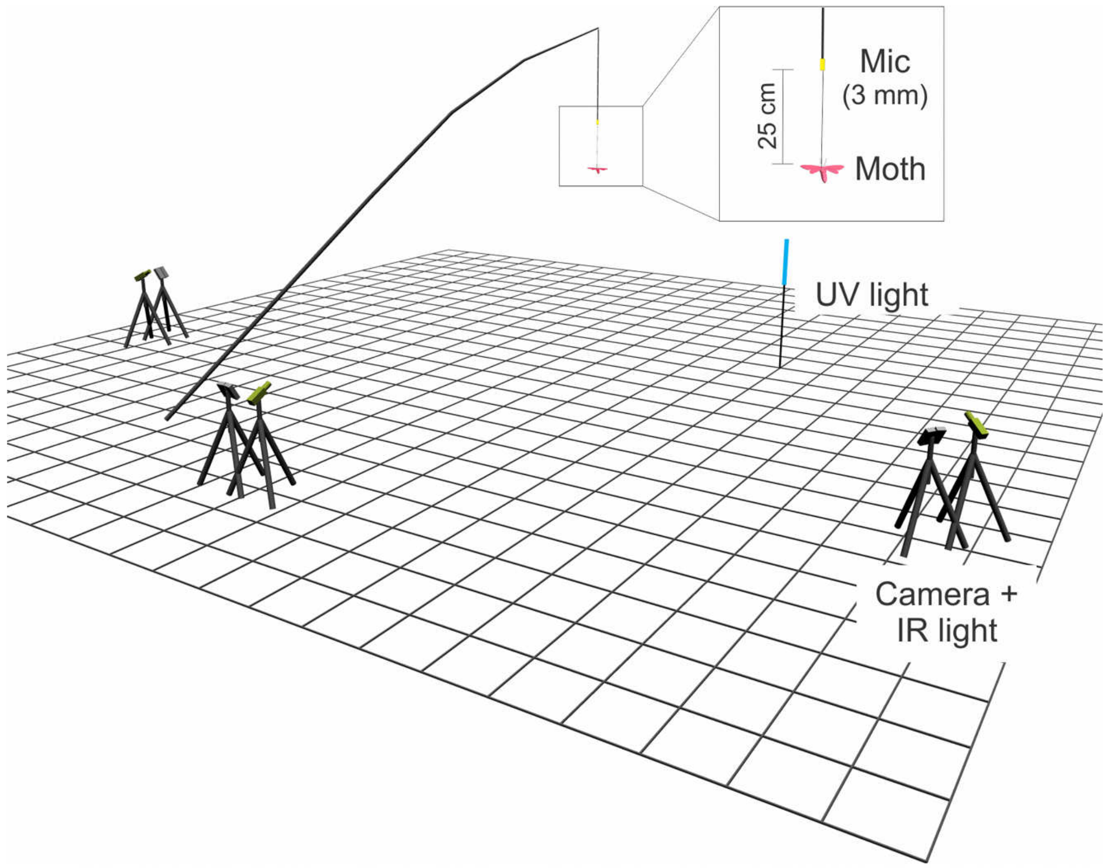
The clicks may have other functions like startling the predator (startle hypothesis) or advertising to the predator that the prey is noxious ("acoustic aposematism") (aposematism hypothesis) (Conner and Corcoran 2012) [14]. Figure 1.10 shows the predated behaviour of the bats based on these hypotheses.



(Based on Corcoran et al 2009 figure 2A p326)

Figure 1.10 - Predation of bat's behaviour depending on reason for clicks by moth.

[12] But only if the clicks precede the echo by 2 ms (Conner and Corcoran 2012).
[13] These take place in dark, sound-attenuated rooms with high-frequency microphones and infrared-sensitive video cameras with tethered prey (figure 1.11).
[14] The startle hypothesis and the jamming hypothesis suggest that the sounds made by the moth disorientate the bat and thereby reduce the effectiveness of the capture strategy, while the aposematism hypothesis influences the decision to attack (Conner and Corcoran 2012).



(Three infrared (IR) cameras recorded bat flight trajectories, positions of tethered and free-flying moths, and positions and directional axes of the ultrasound microphone. An ultraviolet (UV) light attracted free-flying moths and foraging bats to the observation area. In the experiment a silent or clicking moth was tethered and suspended along with a miniature (3 mm diameter) microphone from a 10 m telescoping pole. The microphone's close proximity to the tethered moth allowed for estimating bat call intensities emitted in the moth's direction (10 cm from the bat's mouth) and arriving at the moth for attacks on the tethered moth).

(Source: Corcoran et al 2013 figure 3)

Figure 1.11 - Representation of experimental set-up (as used by Corcoran et al 2013).

i) Startle hypothesis - The clicks will startle the predator and give the prey a momentary advantage during which to escape. There is the possibility that bats will be startled the first time, but soon they will habituate (ie: no longer startled by sound) [15]. Corcoran et al (2011) found that bat habituation to Grote's bertholdia (tiger moth) (Bertholdia trigona) sounds took up to forty occasions on two nights, whereas Bates and Fenton (1990) only three presentations on one night needed for dogbane tiger moths (Cycnia tenera) click habituation. The startle hypothesis is best for naive bats (Conner and Corcoran 2012).

[15] After habituation the clicks "act as a dinner bell" for bats (Miller and Surlykke 2001).

ii) Aposematism hypothesis - This strategy is most effective for bats that have learned the association between the sound and the unpleasant taste.

Hristov and Conner (2005) compared the capture rate by big brown bats (Eptesicus fuscus) over seven nights of moths using sounds to signal unpalatability (ie: that the moth uses chemical defences) and to startle or not. In the experiment where moths were tethered, there were four conditions - unpalatable moths producing sounds (C+S+), unpalatable moths that do not produce sounds (C+S-), palatable moths that produce sounds (C-S+), and palatable moths that do not produce sounds (C-S-). The percentage of moths captured was significantly less in the C+S+ condition over the study.

Where bats have learned that moths who make sounds are unpalatable, there is room for Batesian mimicry. This is where a palatable species exploits this relationship by making sounds. Milkweed tiger moths (Euchaetes egle), for example, produce no chemical defence defences (ie: are palatable to bats), but live close to dogbane tiger moths (unpalatable), and produce clicks. Barber and Conner (2007) showed this behaviour in a laboratory over eleven nights. Naive big brown bats and red bats (Lasiuris borealis) were offered dogbane tiger moths over the first five successive nights. After the first night, the bats learned that the clicks produced by these moths was associated with unpalatability. On nights 6-10, the bats were offered the mimics (clicking, but palatable) which they did not attack. On the final night, the mimics were offered with the inability to make sounds, and they were eaten.

Other Strategies

Some moths also have hearing attuned to the frequency of the bats' echolocation ("bat detectors") [16] [17]. Detecting 40 kHz sounds at between 6.5 - 37 metres gives the moth several tenths of a second to avoid capture. For example, hawk moths change flight speed in response to echolocation (Miller and Surlykke 2001).

Other strategies to avoid bats include living in bat-free environments (eg: Faroe Islands in North Atlantic), or being active at times of the year when bats not (eg: Rileyana fovea in Central Europe active in late

[16] "Bat detectors" aid prey's primary defences (that avoid detection by predators) (eg: fly in different direction) and secondary defences (that increase survival after detection) (eg: complex aerobatic manoeuvres) (Edmunds 1974).

[17] "Bat detectors" have also been found in some species of tiger beetles, praying mantids, and crickets, for example (Conner and Corcoran 2012).

October/early November) or during the day (Miller and Surlykke 2001).

1.3. BATS RESPOND TO MOTHS

Goerlitz et al (2010) reported an example of bats responding to the evolution of counter-measures by moths by the Western barbastelle (Barbastella barbastellus). This species of bat has evolved a lowered intensity of echolocation which cannot be heard by the moths' "bat detectors" [18]. This form of "stealth detection" has a cost in that the distance of its effectiveness is reduced three-fourfold compared to echolocation that moths can hear (Conner and Corcoran 2012).

Bats could change their frequency (either too low or too high for the hearing of moths), or send shorter signals. But very low frequencies produce reduced resolution which means only large insects detectable, and shorter echoes provide less information (Miller and Surlykke 2001).

Other strategies observed by bats include (Conner and Corcoran 2012):

- Big brown bats do not increase the repetition rate of calls as close to capturing moth, thereby removing a clue to the prey to take evasive action.

- Red bats approach prey from below, and thereby anticipate an evasive dropping manoeuvre by the moth.

In any given environment, Baronchelli et al (2013) outlined three types of organisms - "specialists" (evolutionary adapted to the environment - ie: increased ability to survive and reproduce), "generalists" (evolutionary fitness independent of environment), and "maladapted" (ie: reduced ability to survive and reproduce).

In stable environments (ie: unchanging aspect of a physical habitat), specialists will have the most offspring, while in rapidly changing environments, generalists have the best evolutionary strategy.

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2. THEORY OF REASONED ACTION AND PLANNED BEHAVIOUR

The ability to predict behaviour from a knowledge of a person's attitudes is a highly desirable ability. But the simple attitude-behaviour link does not hold (Taylor 2012). This has led to more complex models like the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) (figure 2.1) which predicted behavioural intention and behaviour from attitude (and subjective norm - ie: perceived social norms). Ajzen (1988) observed that the "theory of reasoned action was developed explicitly to deal with purely volitional behaviours. In this context it has proved quite successful. Complications are encountered, however, when we try to apply the theory to behaviours that are not fully under volitional control" (quoted in Taylor 2012 p76).

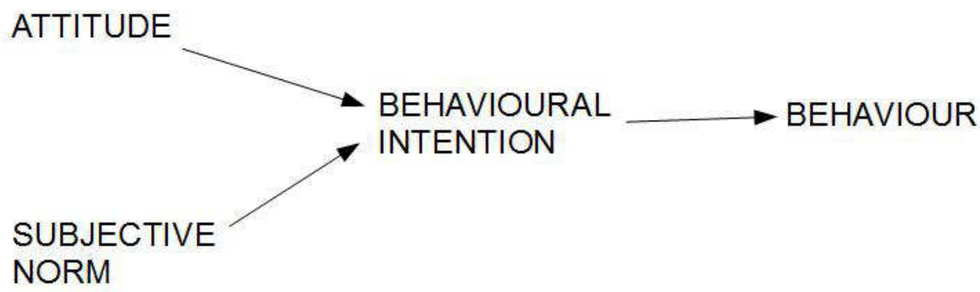

Figure 2.1 - Basic theory of reasoned action.

The theory of planned behaviour (TPB) (Ajzen 1985) (figure 2.2) extended the TRA by adding perceived behavioural control, which "refers to the perceived ease or difficulty of performing the behaviour and it is assumed to reflect past experience as well as anticipated impediments and obstacles" (Ajzen 1988 quoted in Taylor 2012 pp77-78).

Madden et al (1992) compared the two theories. A group of US students were asked to list behaviours that they planned to do regularly over the following two weeks. The most popular ten behaviours were chosen for the study: exercise regularly, get a good night's sleep, talk to a close friend, do laundry, avoid caffeine, go shopping with a friend, rent a video cassette, take vitamin supplements, listen to an album, and wash car.

Then 82 undergraduate business students were asked about their intention to perform these behaviours in the following fortnight (on a seven-point scale) as well as their attitudes, subjective norms, and perceived

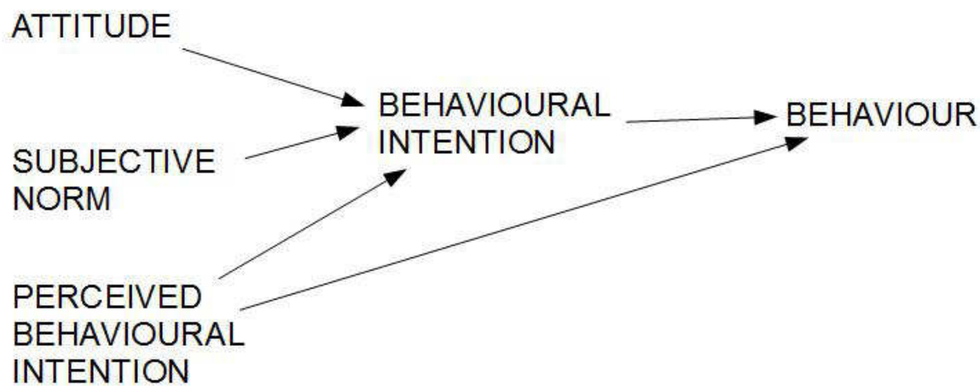

Figure 2.2 - Basic theory of planned behaviour.

behavioural control in relation to the behaviours (baseline). Two weeks later the students were asked how many times they had performed each of the behaviours in the preceding fortnight (follow-up).

Attitudes towards the behaviours at baseline were measured using the semantic differential scale (eg: good-bad), the subjective norms by items like, "most people who are important to me think I should _ during the next two weeks", and perceived behaviour control by items like, "if I wanted to, I could easily _ in the next two weeks".

After statistical analysis it was found that the ability to predict the behaviour was enhanced by inclusion of perceived behavioural control (TPB) compared to without it (TRA).

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3. STRESS, IMMUNE SYSTEM AND CANCER

3.1. STRESS AND IMMUNITY

Stress reduces the effectiveness of the immune system, and a positive mental state can aid it. But Segerstrom (2007) asked: "why the most psychological healthy individuals sometimes have the least robust immune systems". She answered with the ideas from "ecological immunology" (Barnard and Behnke 2001). This sees the body as a system that allocates energy to different organs as required, and "health is not necessarily reflected in the functioning of the immune system, but in whether that functioning is adaptively prioritised" (Segerstrom 2007).

For example, when the immune system is fighting infection with a fever, this is costly in terms of calories, and the body system compensates with decreased activity and increased fatigue and sleep. Thus the immune system has more energy available for it. In times of stress the immune system is given less resources as energy is used to combat the stress; thus the vulnerability to illness in situations of long-term stress. Segerstrom (2007) argued that energy available to the immune system will be reduced when there is an opportunity for resource acquisition as well (eg: mice preparing for a mating opportunity had more parasitic infections).

In terms of psychology, "dispositional optimism" is usually seen as beneficial to health. Such individuals view the future in a positive light and suffer less illness. Segerstrom (2007) reported that among US law students she studied, this was not completely true. Some dispositional optimists were healthier than the average, but some were also less healthy. The key was the demands on their time and energy. In situations of low demands, optimism was associated with good health, but the opposite in high demand situations. Segerstrom (2007) believed that optimists allocated more energy to actively coping with stressors (ie: trying to solve or remove the stressor) in the latter situation, and this left less energy for the immune system. Less optimistic individuals used more passive coping strategies which takes up less energy.

Another contradiction is seen in the case of social networks. Generally, social networks (ie: presence of others) buffers against stress and it is better than experiencing the stress alone. But researchers have found that individuals with large social networks can have more illness than the average in highly stressful situations. Segerstrom (2007) explained it thus: social networks can demand "significant energy to maintain", leaving less energy for the immune system to fight infection.

Though exercise is generally beneficial for health, it can also suppress the immune system. Ibis et al (2012) reported decreases in certain aspects of immune system function up to 24 hours after intensive exercise.

Eighteen students at a Turkish university performed forty-five minutes on an exercise bicycle at 50% Max VO^2 (aerobic exercise) [19], and later until exhausted at 120% Max VO^2 (anaerobic exercise) (figure 3.1). Blood samples were taken before, immediately after, and 24 hours after the exercise. The anaerobic exercise was more stressful and suppressed the immune system

(Source: Cosmed)

Figure 3.1 - Example of how Max VO^2 is measured.

[19] Max VO^2 = maximal oxygen consumption.

3.1.1. Wound Healing

Over the last thirty years it has become clear that wound healing is longer/poorer among stressed individuals. Recent research has suggested that psychological factors could also improve wound healing and recovery (Broadbent and Koschwanez 2012). These factors include:

a) Positive affect/mood.

b) Positive coping style - eg: forgiving others.

c) Social support - eg: mice housed with others self- administered less painkillers (in water) after surgery than mice housed alone (Pham et al 2010).

d) Environmental enrichment - eg: hospital patients in rooms with a view had shorter stays and less painkiller use than in rooms with no view (Ulrich 1984).

3.2. CANCER

Research with animals (eg: Giraldi et al 1994) and humans (eg: Giraldi et al 2010) show a positive correlation between stress and the size of cancer tumours and/or stress and metastatis (the migration of cancer cells to a different part of the body).

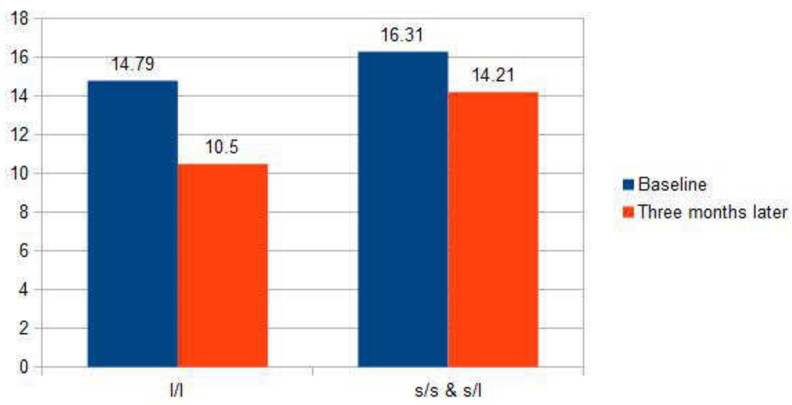
The psychological state of an individual and coping with cancer is seen in the response to the diagnosis, the choice and response to the treatment, and to follow-up. The mental adaptation has been categorised as hopelessness-helplessness, fighting spirit, fatalism/stoic acceptance, denial/avoidance, and anxious preoccupation. The Mental Adjustment to Cancer (MAC) Scale is commonly used to measure these.

Watson et al (1999) found that women with breast cancer showing denial or fighting spirit in response to their diagnosis were more likely to survive at five years than those women showing stoic acceptance or hopelessness-helplessness.

In a different area of research, Caspi et al (2003) found that a "short" version of a gene related to serotonin was associated with depression in response to stressful life events, but not for individuals with the "long" version of the gene.

Schillani et al (2012) investigated mental adaptation and the serotonin gene version among 48 women with breast cancer (mammary carcinoma) in Italy. Three women had the "short" version (s/s) of the gene and nineteen the "long" (l/l) version with the remainder having a combination (s/l). The mental adaptation to cancer was measured by an Italian version of the Mini-MAC Scale, which was completed at baseline in 2008-9 and three months later [20].

Anxious preoccupation was found to be related to the version of the serotonin gene. Individuals with the l/l version showed a significantly greater decline in anxious preoccupation over the three months than the other two gene groups (means: -4.3 vs -2.1; p = 0.023) (figure 3.2).



(Data from Schillani et al 2012 table 3 p325)

Figure 3.2 - Mean anxious preoccupation scores on Mini-MAC Scale.

On the other hand, Schillani et al (2010) found the l/l version was positively associated with depression with hopelessness-helplessness in early breast cancer sufferers not the other versions of the gene.

Schillani et al (2010) had studied 53 early and 73 late (ie: terminally ill) breast cancer sufferers at the same clinic in Trieste, Italy. It was also found that hopelessness-helplessness and anxious preoccupation positively correlated with anxiety and depression in both groups, while avoidance positively correlated with anxious in early sufferers, but negatively correlated with depression in late sufferers (along with fighting spirit).

Andersen et al (2008) reported the benefits of a stress-reduction programme to help individuals with breast cancer over 7-13 years after surgery. Two hundred and twenty-seven women in the Ohio area of the USA, who were surgically treated for the disease were randomly divided into the intervention and or control groups. The

[20] This has 29 items including "I make a positive effort to not think about my illness".

intervention included strategies like progressive muscle relaxation, problem-solving skills, assertive communication training, coping with medicine side effects, and general health and diet advice. Initially, there were four months of weekly sessions and then eight months of monthly sessions (total of 26 sessions).

The outcome measures were disease recurrence (defined as the detection of cancer in the breast or elsewhere in the body), and survival. Health measures were taken at four and twelve months after surgery, every six months up to five years, and annually subsequently.

The average follow-up of eleven years was taken at October 2007 and included information about disease recurrence for 212 women and mortality for the whole sample. Disease recurrence was found in 29 women in the intervention group and 33 in the control group. After controlling for variables like tumour size, this was significant less risk for the intervention group (hazard ratio: 0.55; p = 0.034) [21].

In terms of death, 24 in the intervention group and thirty in the control group. This was significant less risk for the intervention again (hazard ratio: 0.44; p = 0.016).

3.3. APPENDIX 3A - PROBABILITY

Probability is a measure of the likelihood of an event happening.

Three main conceptual approaches (Mann 1995):

i) Classical probability - two or more events that have the same probability of occurring (eg: head or tails when tossing a coin).

$$\text{Probability of head} = \frac{1}{\text{total number of possible outcomes}} = \frac{1}{2} = .50\ (50\%)$$

ii) Relative frequency concept of probability - how often an outcome will occur when an event is required

Probability of next individual randomly chosen will have a disease when 10 individuals in a group of 500 have the disease

$$= \frac{\text{frequency of disease}}{\text{total number}} = \frac{10}{500} = .02\ (2\%)$$

[21] Such statistics are based on concepts like probability (appendix 3A) and significance (appendix 3B).

iii) Subjective probability - probability assigned to an event based on subjective judgment.

There are also concepts like (Mann 1995):

a) Marginal (or simple) probability: probability of a single event without reference to other events

Probability of selecting a male in a sample of 60 males and 40 females

$$= \frac{\text{Number of males}}{\text{Total number}} = \frac{60}{100} = .60\ (60\%)$$

b) Conditional probability: likelihood of an event occurring given another event

Probability of selecting a young male in a sample of 60 males where 15 are young and 45 are old

$$= \frac{\text{Number of young males}}{\text{Total number}} = \frac{15}{60} = .25\ (25\%)$$

c) Joint probability: probability of interaction of two events

Probability of selecting young female in sample of 60 males (15 young/45 old) and 40 females (20 young/20 old)

$$= \frac{\text{Total females}}{\text{Total people}} \times \frac{\text{Total young females}}{\text{Total female}}$$

$$= \frac{40}{100} \times \frac{20}{40} = .20\ (20\%)$$

d) Addition rate: probability of the combination of two events

	young	middle-aged	old	total
male	45	15	10	70
female	90	110	30	230
totals	135	125	40	300

Probability of selecting a random person who is male and young

(i) Probability of male = $\frac{\text{total male}}{\text{total people}} = \frac{70}{300} = .233$

(ii) Probability of young =

$$\frac{\text{total young}}{\text{total people}} = \frac{135}{300} = .450$$

(iii) Joint probability

$$= \frac{\text{total male}}{\text{total people}} \times \frac{\text{total young male}}{\text{total male}} = \frac{70}{300} \times \frac{45}{70} = .150$$

(iv) Addition rule

= (i) + (ii) - (iii) [22] = .233 + .450 - .150 = .533 (53.3%)

e) Addition for mutually exclusive events

Probability of selecting a young or old individual

(ia) Probability of young =

$$\frac{\text{total young}}{\text{total people}} = \frac{135}{300} = .450$$

(iia) Probability of old =

$$\frac{\text{total old}}{\text{total people}} = \frac{40}{300} = .133$$

(iiia) Addition rule

= (ia) + (iia) = .450 + .133 = .583 (58.3%)

f) Revision of probabilities after more information obtained (Bayes theorem)

Two driving test examiners - A sees 55% of testees and passes 70% and fails 30%; B sees 45% of testees and passes 80% and fails 20%

Random selection of 1 failure - what is probability that A was examiner?

(ib) Probability seen by A = .55
(iib) Probability seen by B = .45
(iiib) Probability fail by A = .30
(ivb) Probability fail by B = .20
(vb) Probability pass by A = .70
(vib) Probability pass by B = .80

$$= \frac{\text{(ib)} \times \text{(iiib)}}{[\text{(ib)} \times \text{(iiib)}] + [\text{(iib)} \times \text{(ivb)}]} = .647\ (64.7\%)$$

Random selection of 1 pass - what is probability that A was examiner?

$$= \frac{\text{(ib)} \times \text{(iiib)}}{[\text{(ib)} \times \text{(vb)}] + [\text{(iib)} \times \text{(vib)}]} = .517\ (51.7\%)$$

[22] Subtraction to avoid double counting (Mann 1995).

3.4. APPENDIX 3B - SIGNIFICANCE ISSUES

1. Use of significance

Higgs (2013) lamented the overuse of significance in relation to quantitative data in all disciplines, and the loss of distinction between the everyday use of the word (significant = important) and the statistical use. "The word carries strong connotations from its everyday usage that are difficult, if not impossible, to let go of simply because we find ourselves interpreting statistical results" (Higgs 2012 p7).

Holbert (2013) suggested the use of the word "chance" instead. For example, in a study with a p-value of 0.038 for the difference between the means of two independent samples, the author might say: "in the absence of a real difference between the populations being compared, a difference as large as was observed in this study would occur by chance only 3.8% of the time", or "in the absence of a real difference between the populations being compared, random sampling would produce a difference as large as that observed in this study only 3.8% of the time".

2. Significance level used

The significance level of $p = 0.05$ (or 1 in 20) was described as convenient "in judging whether a deviation is to be considered significant or not" by Fisher in 1944, and became fixed in stone (Higgs 2013). But Fisher (1973) suggested more flexibility about the level of significance.

3. Significance and significant

Gelman and Stern (2006) questioned the practice of comparing significant levels as evidence of the strength of the findings. For example, an experimenter performs three comparisons of background noise to silence on memory recall. Comparison 1 is music versus silence, comparison 2 is talking versus silence, and finally, random noise versus silence (comparison 3). Let us say in this hypothetical example that the mean number of words recalled is significantly different in all three comparison, but varies thus: $p<0.05$ (comparison 1), $p<0.01$ (comparison 2), and $p<0.001$ (comparison 3). Gelman and Stern (2006) would argue that it is a mistake to suggest different effects of background noise on memory based on the different significant levels. For example, the difference in significance levels "could be explained by sampling variability and do not necessarily represent real features of the underlying parameters" (Gelman and

Stern 2006 p331).

4. Objectivity

Berger and Berry (1988) noted that "statistical analysis is used to give the seal of objectivity to conclusions. Yet this general perception of the objectivity of statistics, and perhaps of science in general, may be misguided (p159)". The authors did not want to reject statistical analysis, but "to acknowledge the subjectivity inherent in the interpretation of data".

In an ongoing study, like a longitudinal one, which follows up participants at different times, there is the issue of when to stop the study. For example, when comparing the effects of a treatment against no treatment, the first follow-up may find a significant difference between the two groups. If the study stops now, the results are reported thus. But the study continues, and a later follow-up finds no significant difference. Should the study be stopped now or have a third follow-up at a later date? [23] There is not necessarily a right or wrong answer, but it shows the subjectivity involved in data collection and analysis.

3.5. REFERENCES

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