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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://psychologywritings.synthasite.com/ and http://kmbpsychology.jottit.com.

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1.1. INTRODUCTION

Schwartz et al (2017) noted "the importance of daily and annual timing for individual fitness, with deviations from optimal timing possibly resulting in reduced foraging success, survival and reproductive output" (p1). Helm et al (2017) agreed: "Getting the timing right provides legions of interesting adaptive problems that organisms have to solve. Animals live in a world where the abundance of resources and the incidence of threats fluctuate on daily, seasonal and potentially further temporal scales" (p7).

Biological rhythms are often studied in artificial and controlled conditions as in laboratories, but the concept of "wild clocks" is used for studies of the rhythms in the real world (Helm et al 2017) [1].

Two key aspects are endogenous rhythms ("internal clock time") and external rhythms. Helm et al (2017) argued that "to properly understand an organism's manifest timing, several components of 'time' must be looked at simultaneously, of which some are external (environmental factors) and others internal" (p3). The synchronisation of the two is ideal, and "zeitgebers" (cues like morning sunlight) are involved in the entrainment of the internal rhythms.

Researchers also distinguish between abiotic and biotic time. The latter refers to the living environment of the individual and other animals that influence rhythms, while abiotic time is the non-living environment (eg: duration of light and darkness) (Schwartz et al 2017).

[1] Talking mostly in relation to insects, Denlinger et al (2017) stated: "Wild clocks offer both a curse and a blessing. While wild clocks lack the genetic tools readily available in model systems, the natural world offers an incredibly rich diversity of biological clocks that can be probed for understanding the timing of seasonal activity" (p8).

An example of predator-prey interactions and timings can be seen with the kestrel (predator bird) and the vole (prey mammal). Voles forage outside their burrows a few times a day based on an internal timing system [2]. Kestrels also hunt based on a daily routine, but they adapt their flight times in relation to the hunting success of the preceding day (Helm et al 2017).

While Cooper's hawks were most active when prey (small songbirds) were most abundant (around sunrise and sunset) (Roth and Lima 2007). This is known as "temporal niche selection" (van der Veen et al 2017).

Temporal niche switching does occur - eg: prey becoming diurnal (active in the day) if night-time predation is high or vice versa (van der Veen et al 2017).

Helm et al (2017) distinguished different types of "clocks" and their flexibility:

i) Endogenous - relatively unchanged by environmental cues (eg: body temperature).

ii) Daily fluctuations - eg: the male moth responds differently to female pheromones at different times of the day.

iii) Responsive to entrainment - eg: exposure to light before the morning phase will advance activity rhythms, but exposure in the late evening phase will delay the rhythm.

iv) "Masking" - environmental factors that modify internal rhythms, like an "owl" human (who prefers late nights) forced to work early morning shifts during the week, but reverts to preference at weekends. "As a consequence of cultural time tables, many humans incur a sleep deficit over the work week termed 'social jet lag' [Roenneberg and Merrow 2016]" (Helm et al 2017 p9).

v) Highly flexible - the modification of rhythms depending on the situation, like a bumblebee queen which changes her daily activity based on the presence of a brood or not (eg: 24 hour-activity in the former vs 12 hours).

In terms of cues, there is variety in their effect. For example, northern birds migrating south in the autumn is triggered by shortening days, while in the spring, it is the lengthening that is the trigger. There may also be an interaction with environmental temperature (Helm et al 2017).

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[2] The common vole feeds every 2-3 hours throughout the 24-hour period (van der Veen et al 2017).

Added to the environmental cues, there is "chronotype", which is the individual's "preference" for "early" ("lark") or "late" ("owl"). "Chronotype can refer to rhythms of diverse processes, such as locomotion, body temperature, hormone or metabolite levels, gene expression, cognitive function, eating or sleeping. Individuals are considered 'early' or 'late' not in absolute terms, but relative to conspecifics measured under similar conditions" (Helm et al 2017 p11).

Organisms have "a vast network of clocks and rhythms distributed across tissues throughout the body" (van der Veen 2017 p1). The suprachiasmatic nucleus (SCN) of the hypothalamus is the "master clock", and non-SCN clocks are the "peripheral timing system" (van der Veen 2017). Several clocks may be involved in the timing of a single behaviour (van der Veen 2017).

1.2. METHODOLOGY

Dominoni et al (2017) noted that the study of biological rhythms (chronobiology) has been "largely dominated by studies of just a few model organisms under standardised laboratory conditions" (p1). They continued, though "controlled laboratory studies are essential to investigate the proximate mechanisms behind biological rhythms, they offer little insight about the diversity of temporal strategies that free-living animals may adopt and the fitness consequences of an eco-evolutionary process that takes place in the 'real world'" (Dominoni et al 2017 p1) [3].

Studying "wild clocks" is aided by technological developments. For example, lightweight GPS-tracking, accelerometers, and EEG recorders placed on frigatebirds, found them flying for up to ten days non-stop over the ocean (ie: sleeping in mid-flight) (Rattenberg et al 2016). The GPS tracking devices allow the position of the animal to be established via stationary satellites, while accelerometers record movement, and the EEG recorders measure electrical activity in the brain from the surface of the skull.

"Wild clocks" research has produced unexpected findings. For example, Bulla et al's (2016) study of 32 shorebird species with an array of recorders and video cameras found "substantial within- and between-species variation in incubation rhythms", and the findings

[3] Laboratory mice housed in a large outdoor enclosure for a two-year period, which had natural weather conditions, showed changes in timings compared to nocturnal behaviour activity in laboratory conditions (Daan et al 2011).

"indicate that under natural conditions social synchronisation can generate far more diverse behavioural rhythms than previously expected (eg: from studies of captive animals...), and that the incubation rhythms often defy the assumptions of entrainment to the 24-h day–night cycle" (Dominoni et al 2017 p8).

Rattenberg et al (2017) concentrated on studying sleep in the wild.

Animals kept in laboratories usually have food and water provided ad libitum (freely available as much as wanted), ambient conditions, and often solitary housing. As well as removing normal survival challenges, this environment may actually be stressful for wild animals. "For example, animals may perceive the novelty of the laboratory setting, combined with absent or artificial refuges and visits by caretakers and researchers as an environment of elevated and persistent danger. In such situations, animals may lack the means to reduce the threat with adaptive behavioural responses (eg: hiding, flocking or fleeing). A wild animal brought into such a situation may never fully acclimate and instead develop changes in hormone and neurotransmitter levels brought on by recurring stress that also can influence sleep. Depending on the species, these factors can lead to captive animals sleeping more or less than their wild conspecifics" (Rattenberg et al 2017 p3).

The majority of around 100 mammalian species studied in sleep laboratories are wild animals captured, or domesticated ones (Rattenberg et al 2017).

Studying sleep in the wild also shows differences between individuals of the same species. "For example, under certain ecological circumstances, individuals with an ability to perform adaptively on little sleep may be favoured over individuals requiring more sleep to perform at comparable levels" (Rattenberg et al 2017 p3). Lesku et al (2012), for instance, found that short-sleeping male pectoral sandpipers in the Arctic sired more offspring.

In terms of the methods used in studying sleep in the wild, it includes (Rattenberg et al 2017):

a) Direct human observation - Time sampling may not capture the whole picture, while animals may be reluctant to sleep when they know an observer is present.

b) Video recording - A better way to capture long periods of time, but limited to behaviour within the camera's coverage.

Observation of sleep generally is not easy, for example, as some animals sleep with one eye open (eg: mallard ducks) or both open (eg: dolphins).

Observation struggles to distinguish between types of sleep. Though twitching can be a sign of REM (rapid eye movement) sleep (eg: mice; McShane et al 2012), or posture changes (eg: giraffes; Tobler et al 1996).

c) Actigraphy - Movement data from tags or accelerometry, for example.

But: requires the animal to stay within reception range of a receiver station with radio tags.

But: depends on what part of the body the activity monitor is attached - eg: "many animals raise their head during brief awakenings, but do not change their overall body position" (Rattenberg et al 2017 p6).

But: detection of "false" movements caused by the environment (eg: waves) and other individuals (eg: preening).

But: twitching during REM sleep could be mistaken as movement.

d) Electrophysiology - Measurement of electrical activity in the brain which can help distinguish REM and NREM sleep. A limited number of non-invasive devices are available at the moment. Also scalp electrodes may be removed, or could interfere with the animal's normal behaviour.

Minimally invasive methods include electrodes inserted under the skin (eg: hibernating lemurs; Blanco et al 2016).

Fully invasive electrodes can be surgically connected to the brain under general anaesthesia. The impact of the surgery is an issue.

Generally, EEG recordings during wakefulness and some types of sleep can look similar, so other methods are needed at the same time (eg: accelerometry).

Rattenberg et al (2017) added these limitations: "Notably, the recordings cannot be monitored in real time and the animal has to be recaptured to remove the logger. Also, although the logger used in the field-based EEG sleep studies to date is relatively light (less than 2 g without a power supply), an obvious trade-off between recording duration and logger mass exists when the size of the battery is taken into consideration. In some cases, the combined mass of the logger and battery may be within the acceptable range for an animal to carry only when placed on the animal's back. In this case, the accelerometer will detect movements of the body, but not those of the head. In addition, when the logger is placed on the back, a cable is needed to run the electrode wires from the head to the logger" (p7).

1.3. REPRODUCTION

Animals required energy to fuel reproduction. A distinction has been made between "capital" and "income" breeders (Drent and Daan 1980). "Capital breeders use energy stored in advance of the breeding season whereas income breeders finance reproduction using concurrent energy intake. Though often described as a dichotomy, it is widely recognised that capital- and income-breeding reflect endpoints of a continuum that exists in nature" (Williams et al 2017 p1).

Biological rhythms (like circannual ones [4]) are involved in seasonal reproduction, like the hormone melatonin, which is secreted during darkness. The amount of melatonin is linked to the length of darkness and daylight.

In terms of energy, gut hormones like leptin and ghrelin are involved, and linked to the gonads, for instance (Williams et al 2017).

Reproduction is timed to match the peak energy demands with the seasonal abundance of food in many species. Animals that cannot store fat are particularly dependent on this (income-breeders), unless they have food caches. Capital-breeders are less tied to food abundance (Williams et al 2017).

Early breeders in a season show a lack of match between reproduction and resources. These animals are often higher-quality individuals, and have higher reproductive success. Early breeding allows for multiple litters/clutches, the opportunity to try again if a litter is lost, and more time for offspring to grow before hibernation, say (Williams et al 2017).

Large mammals have been shown to adjust the length of gestation to high food availability ("surf the green wave"; Drent et al 1978) (eg: bison by as much as fifteen days; Berger 1992).

Capital- and income-breeding strategies can be flexible as in female Arctic ground squirrels. Usually they use fat stores in early gestation, but "in years with early spring and snow melt, females will immediately begin accruing body mass, indicating the use of capital is probably plastic" (Williams et al 2017 p6). While the fresh fly (Sarcophaga crassipalpis) is mostly a capital-breeder for the first clutch of the year, but an income-breeder subsequently (Williams et al 2017).

The opportunity for sexual reproduction is based in sexual selection. This describes particular displays, behaviours or ornaments used by each sex to attract a

[4] Circannual refers to rhythms of the period of one year, while circadian refers to 24 hours.

mate.

These occur at certain times (ie: around the time of seasonal breeding), and so must be linked to biological rhythms.

The timing of the expression of the appropriate characteristics is crucial. Males, for example, who express earlier have fewer competitors and more potential mates (assuming it is not too early). "As a result, males that display a trait early may gain substantial mating success even if the quality of the trait they display is suboptimal, and males that display late may only be successful if their traits are of sufficient quality" (Hau et al 2017 p2).

The photoneuroendocrine systems (PNES) are involved in the process of expression of sexual characteristics, and light is central to them (or more correctly, changing daylength) (Hau et al 2017).

Concentrating on birds, there are two types of timings (Hau et al 2017):

a) Daily - eg: the "dawn chorus" (pre-dawn singing) is a way to attract extra-pair copulations (EPCs) in socially monogamous songbirds. Male blue tits, for instance, who join the dawn chorus first have more EPCs (Poesel et al 2006).

b) Annual - eg: the timing of the moult to colourful breeding plumage. Male superb fairy-wrens who do this earlier father more extra-pair offspring (Dunn and Cockburn 1999).

1.4. INTERACTIONS

The timing of behaviours like foraging is important in changing environments. For example, desert mammals reduce activity in the hottest part of the day to avoid overheating and water loss, and low tide feeders know when foraging opportunities will be available (Kronfeld-Schor et al 2017).

The internal timing system is used in relation to interactions (eg: prey availability and predator avoidance), but the "same features that make the internal timing system advantageous (relative rigidity) may turn disadvantageous when conditions change rapidly" (Kronfeld-Schor et al 2017 p2). Climate change can produce a mismatch as in the case of caribou in Greenland (Post and Forchhammer 2008). The birth of calves is timed to match plant-growing season, so there is sufficient food. Between 1993 and 2006, the onset of plant-growing has advanced 4.6 days, but the calving date has only advanced 3.8 days. "Thus, caribou are getting increasingly mismatched with food availability, with

consequences for reproduction..." (Kronfeld-Schor et al 2017 p7).

To study the timing of behaviours, researchers look for behaviours that evolved that are not adaptive today (what Connell (1980) called "ghost of competition past").
Kronfeld-Schor et al (2017) outlined some examples:

i) Predation risk - This can be reduced by "temporal partitioning", including being less active when predators are active, reducing activity when predators find it easy to capture prey, or changing the appearance to make it difficult for predators (eg: seasonal moult to white or brown fur to match the presence of snow by snowshoe hares).
In terms of the "ghost of competition past", Biggins et al (2011) reported on released Siberian polecats and black-footed ferrets into predator-free environments. The latter remained nocturnally active (which had evolved to avoid day predators like the coyote), while the polecats were active during the day (based on avoiding the nocturnal Asian red fox).

ii) Food availability - Knowing when the (hourly, daily, tidal, or seasonal) "food peaks" appear. "Circatidal" behaviour, for instance, has been studied in oystercatchers who forage on exposed mudflats (ie: low tides) (Dann and Koene 1981) (appendix 1A).

iii) Competition - Different species using the same resources, but at different times (eg: prairie voles nocturnal and cotton rats diurnal). "Following an accidental disappearance of cotton rats from a shared habitat, prairie voles continued to use nocturnal hours rather than daylight hours during times cotton rats would co-occur..." (Kronfeld-Schor et al 2017 p5).

iv) Parasitism - "Parasites need to accurately time their activities in order to transmit to suitable hosts in which they can spread and develop. Likewise, hosts need to allocate resources for increasing their immune defences and avoid parasites via, for example, behavioural changes or movements" (Kronfeld-Schor et al 2017 p6).

Some interactions are desirable and require temporal co-ordination, like bees and flowers. Bees need to know when flowers will be open each day, and when they are available in the year. "Most bee species are day active (diurnal). Relying on the circadian clock to anticipate the time of sunset and sunrise may enable diurnal bees to most efficiently exploit the hours with sufficient sunlight for foraging. Moreover, there can be competitive advantages for bees in arriving early at flowers that

have high amounts of nectar and pollen" (Bloch et al 2017 p4).

Evidence for an internal clock regulating bee behaviour is seen in "morning anticipation". Bees in their nest show increased locomotor activity before sunrise (Bloch et al 2017).

1.5. INSECTS

In species that migration or hibernate/diapause to cope with winter, they must be able to anticipate the upcoming season, and daylength is the key cue here. In this case of insects, this cue is relevant, but so are other processes, including (Denlinger et al 2017):

a) "Obligate diapause" - Insects that complete one generation each year may automatically enter diapause at a fixed developmental stage, but environmental cues are needed to end the diapause.

b) Low temperature - eg: certain moths.

c) Insects living near the equator experience little changes in daylength, so cues like temperature, moisture, and changes in food quality are used.

d) Short-lived insects like a midge in Antarctica (Belgica antarctica) is active all day and night. "Although the midge has the full complement of circadian clock genes, the genes fail to show the cyclic pattern of expression seen in species from temperate latitudes" (Denlinger et al 2017 p2).

e) "Maternal effects" - "For example, in the flesh fly Sarcophaga bullata, if the mother has over-wintered in pupal diapause, her progeny are unable to enter pupal diapause even if they are exposed to strong diapause-inducing environmental conditions. This mechanism is an adaptive response allowing early spring emergence of the adults without the risk of an untimely entrance into diapause by her progeny that would be exposed to short daylengths of spring and early summer" (Denlinger et al 2017 p3).

1.6. LONG-DISTANCE BIRD MIGRATION

"Observations had strongly suggested that birds timed migration not only by immediate responses to the environment but also by using internal timekeeping mechanisms. Many migratory species are remarkably punctual when they return to their breeding grounds, despite inter-annual differences in local conditions.

Equally, birds have admirable navigational abilities, using among other cues the sun for orientation, whose direction from earth (ie: its azimuth) changes with time of day" (Akesson et al 2017 p1).

Kramer (1957) proposed a "clock and compass" mechanism. But this work was laboratory-based. Recent studies with freely moving birds have suggested a "diversity of patterns and mechanisms" (Akesson et al 2017).

Akesson et al (2017) outlined some challenges for birds which natural selection has "worked" upon:

i) Departing before the bad weather arrives - Light may be important, but there is also circannual clocks involved (eg: spring migration restlessness - Zugunruhe; Gwinner 1986).

ii) Moving through time and space - "Once a bird has commenced its migratory journey, timekeeping plays an important role for navigation and for pacing the progress of migration" (Akesson et al 2017).

iii) Migration as part of the annual cycle - Other cycles, including moulting and breeding, and flexibility towards any of these can be both advantageous (eg: responding to unexpected environmental changes) and disadvantageous. The latter includes, for instance, "the risk of mistiming at subsequent destinations, for example, delayed breeding site arrival resulting from extended stop-over during spring migration, or, conversely after rushed stopover, premature return to areas that might still be in winter conditions" (Akesson et al 2017 p4). Birds, then, must compensate for changes in one activity.

iv) Adjusting to climate change - There are already signs of earlier breeding and migration in some species (Akesson et al 2017).

1.7. HUMANS

1.7.1. Daily Rhythms

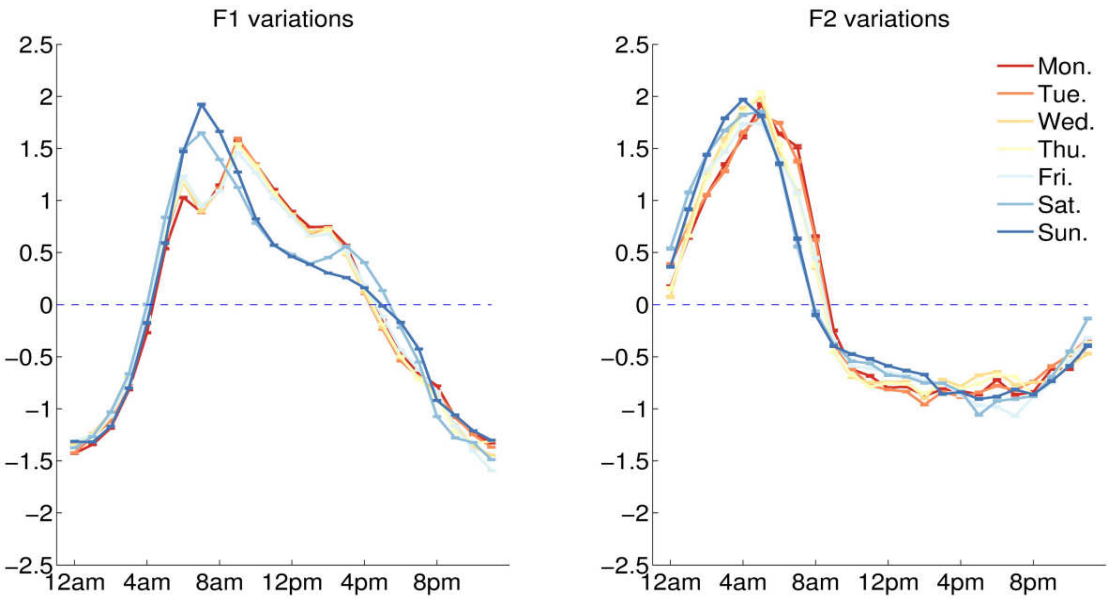
Based on the analysis of Twitter contents, Dzogang et al (2018) found that "language changes dramatically between night and day, reflecting changes in our concerns and underlying cognitive and emotional processes. These shifts occur at times associated with major changes in neural activity and hormonal levels" (p1).

Over 800 million tweets between January 2010 and November 2014 in the UK were analysed. Words indicating an observable mental state (73 categories) were sampled

each hour over the 24-hour period to give a diurnal variation profile.

After factor analysis of the data, two factors were distinguished - one peaked between 6 am and 10 am (F1), and the other between 3 am and 5 am (F2). F1 (named "categorical thinking" by the researchers) was associated with "measures of analytical thinking, with the language of drive (eg: power, and achievement), and personal concerns. It is anti-correlated with the language of negative affect and social concerns" (Dzogang et al 2018 p1). F2 ("existential thinking") correlated with existential concerns (eg: death), and anti-correlated with positive emotions (figure 1.1).

These differences in timing "might not necessarily be due only to physiology, and other factors can be at play" (Dzogang et al 2018 p15). But concentrating on the physiological changes over the 24-hour period, "variations of cortisol production are remarkably similar to the diurnal variation of F1, marked by a rapid increase from 3 am to early morning, reaching maximum levels between 6 am and 10 am, then slowly decreasing until the rest of the day. On the other hand, F2 occurs at maximum serotonin activity and minimal cortisol" (Dzogang et al 2018 p15).



(Source: Dzogang et al 2018 figure 6)

Figure 1.1 - Diurnal variations of two factors.

1.7.2. Disrupted Circadian Rhythms

The disruption of circadian rhythms (eg: sleep

patterns) is associated with poor mental health, according to a number of studies, but "much of this work has limitations, which include the use of relatively small or highly selected samples, minimal adjustment for confounders, and subjectively reported measures of circadian function such as chronotype (preference for evening or morning activity)" (Lyall et al 2018 p507).

Lyall et al (2018) tried to overcome these limitations with data from over 90 000 participants in the UK Biobank cohort (ie: large sample). This cohort includes over half a million UK residents aged 37 to 73 years old recruited and baseline assessed at 22 centres between 2006 and 2010 (Sudlow et al 2015) (table 1.1) [5].

Questionnaire and interview	
Sociodemographic	Social class; ethnicity; employment status; marital status; education; income; car ownership
Family history and early life exposures	Family history of major diseases; birth weight; breast feeding; maternal smoking; childhood body size; residence at birth
Psychosocial factors	Neurosis; depression (including bi-polar spectrum disorder); social support
Environmental factors	Current address; current (or last) occupation; domestic heating and cooking fuel; housing; means of travel; shift work; mobile phone use; sun exposure
Lifestyle	Smoking; alcohol consumption; physical activity; diet; sleep
Health status	Medical history; medications; disability; hearing; sight; sexual and reproductive history
Hearing threshold	Speech reception threshold*
Cognitive function	Pairs matching; reaction time; prospective memory†; fluid intelligence*; numeric memory‡
Physical measures	
Blood pressure and heart rate	two automated measures, one minute apart
Grip strength	Left- and right-hand grip strength
Anthropometrics	Standing and sitting height; weight and bio-impedance; hip and waist circumference
Spirometry	Up to three measures
Bone density‡	Calcaneal ultrasound
Arterial stiffness¶	Pulse wave velocity
Eye examination§	Refractive index, intraocular pressure; acuity; retinal photograph; optical coherence tomography
Fitness test§	Cycle ergometry with electrocardiogram (ECG) heart rate monitoring

* assessed in 170,000 participants;
† assessed in 50,000 participants;
‡measured in one heel for 170,000 participants and in both heels for 320,000 participants;
¶ measured in 170,000 participants;
§ measured in 100,000 participants

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(Source: Sudlow et al 2015 table 2)

Table 1.1 - Data collected at the baseline assessment of UK Biobank.

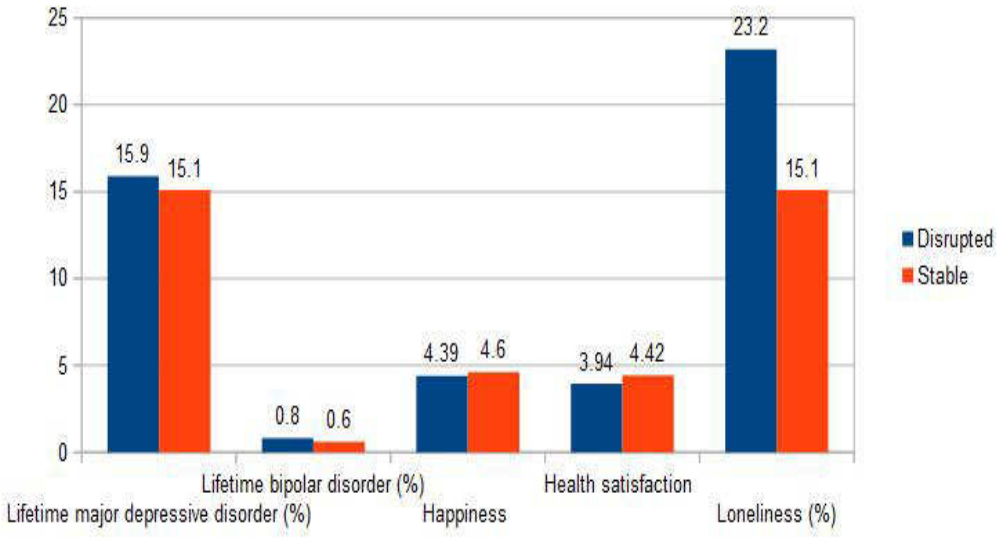
A sub-set of the cohort, which Lyall et al (2018) focused upon, wore an accelerometer for seven days to monitor physical activity (ie: objective measure of circadian activity). Questionnaire data were also collected, including mood and well-being measures, and other information that could be confounding (eg: poverty, season, age).

[5] http://www.ukbiobank.ac.uk/.

For analysis purposes, individuals were divided into those with disrupted circadian rhythms and those not based on accelerometry data. Relative amplitude of activity was used, which is the difference between the most and least active periods of the 24-hour day, and whether this was the same across the seven days. This produced 3477 individuals classified as disrupted circadian rhythms, and 87 628 as stable circadian rhythms.

The disrupted circadian rhythms group reported significantly lower happiness and subjective well-being, and higher rates of lifetime major depressive disorder and bipolar disorder, as well as loneliness, and slower reaction times on computer-based cognitive tests (eg: matching two cards) (figure 1.2).

Lyall et al (2018) noted: "Because of the cross-sectional nature of the data, the current findings cannot speak to the issue of causal associations between circadian disruption and poorer mental health and well-being outcomes. This limitation is compounded by the temporal separation between the recording of baseline demographic and lifestyle variables (2006–10), accelerometry data (2013–14), and the MHQ [mental health questionnaire] (2016–17), particularly because reaction time, neuroticism, and loneliness data were collected before the accelerometry data" (p513).



(Data from Lyall et al 2018 table 2 pp509-510)

Figure 1.2 - Key significant differences between groups with disrupted and stable circadian rhythms.

The negative consequences of poor sleep have been

linked to the disruptive effect of blue-omitting LEDs of electronic devices. "Blue light" exposure at night has been associated with increased risks of breast and prostate cancers, for instance (Fleming 2018).

John O'Hagan of Public Health England is cautious about "the hype around the blue light hazard", though accepting the concerns about disrupted circadian rhythms, at least for some people (Fleming 2018).

1.8. APPENDIX 1A - TIDAL RHYTHMS

Tidal rhythms are different to those of light and dark, and are based around 12.4 hours for the rise and fall of sea levels, 15 days for spring (high-amplitude) and neap (low-amplitude) tides. Organisms living in inter-tidal zones show tidal, semi-lunar (14.8 days), and lunar (29.6 days) cycles (Bulla et al 2017).

Organisms showing sensitivity to these rhythms include (Bulla et al 2017):

i) Tidal - eg: feeding on molluscs at low tide by shorebirds; the "spectacled sea louse" (marine isopod) hides in a sandy burrow during low tide and swims out to forage at high tide.

ii) Semi-lunar - eg: marine midge. "During full and new moon, millions of males and females of the midge emerge from the sea as low tide exposes the habitats where they have developed from eggs to pupae. These adults mate and live for a few hours, so it is critical that they emerge synchronously during those few hours of low tide. The timing of the lowest tide can be predicted from the lunar calendar, but these critical few hours during the day vary from location to location. Thus, the emergence of the marine midge has to rely on two clocks, one circa-semi-lunar or circa-lunar, and the other circadian" (Bulla et al 2017 pp5-6).

iii) Lunar - eg: bristle worm: spawns in a monthly rhythm.

1.9. REFERENCES

Akesson, S et al (2017) Timing avian long-distance migration: From internal clock mechanisms to global flights Philosophical Transactions of the Royal Society B 372, 20160252

Berger, J (1992) Facilitation of reproductive synchrony by gestation adjustment in gregarious mammals: A new hypothesis Ecology 73, 323-327

Biggins, D.E et al (2011) Black-footed ferrets and Siberian polecats as ecological surrogates and ecological equivalents Journal of Mammalogy 92, 710-720

Blanco, M.B et al (2016) Hibernation in a primate: Does sleep occur?

Royal Society Open Science 3, 160282

Bloch, G et al (2017) Time is honey: Circadian clocks of bees and flowers and how their interactions may influence ecological communities Philosophical Transactions of the Royal Society B 372, 20160256

Bulla, M et al (2016) Unexpected diversity in socially synchronised rhythms of shorebirds Nature 540, 109-113

Bulla, M et al (2017) Marine biorhythms: Bridging chronobiology and ecology Philosophical Transactions of the Royal Society B 372, 20160253

Connell, J.H (1980) Diversity and the co-evolution of competitors, or the ghost of competition past Oikos 35, 131-138

Daan, S & Koene, P (1981) On the timing of foraging flights by oysercatchers, Haematopus ostralegus, on tidal mudflats Netherlands Journal of Sea Research 15, 1, 1-22

Daan, S et al (2011) Laboratory mice in the field: Unorthodox daily activity and effects of a dysfunctional circadian clock allele Journal of Biological Rhythms 26, 118-129

Denlinger, D.L et al (2017) Keeping time without a spine: What can the insect clock teach us about seasonal adaptation? Philosophical Transactions of the Royal Society B 372, 20160257

Dominoni, D.M et al (2017) Methods in field chronobiology Philosophical Transactions of the Royal Society B 372, 20160247

Drent, R.H & Daan, S (1980) The prudent parent: Energetic adjustments in avian breeding Ardea 68, 225-252

Drent, R.H et al (1978) Balancing the energy budgets of Arctic breeding geese throughout the annual cycle: A progress report. In Smart, M et al (eds) Proceedings Symposium on Feeding Ecology of Waterfowl Bayern, Germany

Dunn, P.O & Cockburn, A (1999) Extra-pair mate choice and honest signalling in co-operative breeding superb fairy-wrens Evolution 53, 938-946

Dzogang, F et al (2018) Diurnal variations of psychometric indicators in Twitter content PLoS ONE 13, 6, e0197002 (Freely available at http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0197002)

Fleming, A (2018) Tangled up in blue Guardian 29th May, II.4-5

Gwinner, E (1986) Circannual Rhythms: Endogenous Annual Clocks in the Organisation of Seasonal Processes Berlin: Springer

Hau, M et al (2017) Timing as a sexually selected trait: The right mate at the right moment Philosophical Transactions of the Royal Society B 372, 20160249

Helm, B et al (2017) Two sides of a coin: Ecological and chronobiological perspectives of timing in the wild Philosophical Transactions of the Royal Society B 372, 20160246

Kramer, G (1957) Experiments on bird orientation and their interpretation Ibis 99, 196-227

Kronfeld-Schor, N et al (2017) Chronobiology of interspecific interactions in a changing world Philosophical Transactions of the Royal Society B 372, 20160248

Lesku, J.A et al (2012) Adaptive sleep loss in polygynous pectoral sandpipers Science 337, 1654-1658

Lyall, L.M et al (2018) Association of disrupted circadian rhythmicity with mood disorders, subjective well-being, and cognitive function: A cross-sectional study of 91 105 participants from the UK Biobank Lancet Psychiatry

5, 507-514

McShane, B.B et al (2012) Assessing REM sleep in mice using video data Sleep 35, 433-442

Poesel, A et al (2006) Early birds are sexy: Male age, dawn song and extra-pair paternity in blue tits, Cyanistes (formerly Parus) caeruleus Animal Behaviour 72, 531-538

Post, E & Forchhammer, M.C (2008) Climate change reduces reproductive success of an Arctic herbivore through trophic mismatch Philosophical Transactions of the Royal Society B 363, 2367-2373

Rattenberg, N.C et al (2016) Evidence that birds sleep in mid-flight Nature Communications 7, 12468

Rattenberg, N.C et al (2017) Sleep research goes wild: New research methods and approaches to investigate the ecology, evolution and functions of sleep Philosophical Transactions of the Royal Society B 372, 20160251

Roenneberg, T & Merrow, M (2016) The circadian clock and human health Current Biology 26, R432-R443

Roth, T.C & Lima, S.L (2007) The predatory behaviour of wintering Accipter hawks: Temporal patterns in activity of predators and prey Oecologia 152, 169-178

Schwartz, W.J et al (2017) Wild clocks: Preface and glossary Philosophical Transactions of the Royal Society B 372, 20170211

Sudlow, C et al (2015) UK Biobank: An open access resource for identifying the causes of a wide range of complex diseases in middle and old age PLoS Medicine 12, 1-10 (Freely available at http://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001779)

Tobler, I et al (1996) Behavioural sleep in the giraffe (Giraffa camelopardalis) in a zoological garden Journal of Sleep Research 5, 21-32

van der Veen, D.R (2017) Flexible clock systems: Adjusting the temporal programme Philosophical Transactions of the Royal Society B 372, 20160254

Williams, C.T et al (2017) Seasonal reproductive tactics: Annual timing and the capital-to-income breeder continuum Philosophical Transactions of the Royal Society B 372, 20160250

2. HOMEWORK

Appendix 2A - Two earlier studies
Appendix 2B - Bias evaluations

Cooper (1989) defined homework as "tasks assigned to students by school teachers that are meant to be carried out during non-school hours".

Answering the question as to whether homework is beneficial (the homework-achievement relationship) depends on the methodology used in studies. The common methodology of studies include (Hartley 1999):

- Comparison of students doing homework or no homework.
- Comparison of classes doing homework or no homework.
- Matched students within classes (ie: one does homework, the other does not).
- Matched classes (ie: similar characteristics like ability).
- Opportunistic control group - using classes without homework as comparison.

In terms of success of tests (as the outcome measure), earlier studies (appendix 2A) suggested that homework is more effective for older pupils (11 years old onwards) than younger ones (Hartley 1999).

Corno (1996) described homework as a "complicated thing" because of the potential factors that can affect it (eg: influence of parents, subject, students' interest in subject).

In recent years, syntheses of the previous research has become popular. These tend to focus on homework in general (eg: Cooper et al 2006). But Fan et al (2017) preferred to concentrate on two specific subjects - mathematics and science. Previous research is inconsistent (table 2.1).

Fan et al (2017) offered some reasons for the inconsistent findings, including [6]:

a) Measure of achievement - eg: standardised or unstandardised tests.

b) Subject matter.

[6] Studies tend not to pay attention to the marking of homework, but this can be biased (appendix 2B).

	MATHEMATICS	SCIENCE
Positive relationship	Pelletier (2005 quoted in Fan et al 2017): % of homework completed and % of homework correct associated with average test scores (143 3rd graders in USA)	Fernandez-Alonso et al (2015): frequency of homework, time spent, and effort all correlate with science test score (7725 2nd year secondary education in Spain)
Negative relationship	De Jong et al (2000): 1394 junior high school students in Netherlands	No example
No relationship	House (2002): 10 107 13 year-olds in Japan	House (2000) 6031 13 year-olds in Hong Kong
Within study differences	Omlin-Ruback (2009 quoted in Fan et al 2017): type of homework: skill practice and mathematics test score - positive; direct practice - negative; other subject homework and mathematics test score - no relationship (US 5th grade students)	No example

Table 2.1 - Examples of studies with different findings about homework and achievement in mathematics and science (Fan et al 2017).

c) Sample.

d) Homework measures - eg: time spent on homework; homework frequency; homework effort.

e) Age of students.

f) Country of study.

Fan et al (2017) performed their meta-analysis on studies between 1986 and 2015, and particularly excluded college students, and general homework. There were 115 studies found, of which 28 of them met the full inclusion criteria. Overall, there was "a positive, although somewhat weak, relationship between homework and performance in math/science areas" (p44).

The positive effect of homework on achievement was strongest in studies with US students, and weakest with Asian samples, and stronger for elementary level pupils (5-7 years old) while weakest for middle school age (8-11 years old). Fan et al (2017) explained the difference in the homework-achievement relationship based on age thus:

- Short, frequent, homework assignments effective for younger child.

- Homework for younger children specifically to improve skills.

- Parental involvement - "Parents have greater mastery of the subject matter covered in the elementary grades" (p49).

- Difficulties generally for children in the transition to middle school.

Any meta-analysis is only as good as the studies included. Fan et al (2017) included only studies in written in English, and "a relatively short number of studies were found at the early elementary school grades, particularly concerning the homework-achievement relationship in science" (p51).

APPENDIX 2A - TWO EARLIER STUDIES

1. Holmes and Croll (1989)

Holmes and Croll (1989) analysed data collected on seventy-nine boys at a single-sex grammar school in England from entry (at 11 years old) to national examinations ("O" level or CSE at 16 years old). Concentrating on the third year (13-14 years old), the boys were to do 25 minutes homework per subject with three subjects per evening (ie: 75 minutes per night). Based on self-reports, the amount varied between less than 30 minutes (13% of sample), 30-59 minutes (52%), 60-75 minutes (22%), and more than 75 minutes (13%). These were the four groups used for comparison of internal school examination scores at the end of the year (outcome measure). There was a positive correlation between average time spent on homework generally and average internal examination score for ten subjects (and with national examination scores at 16 years old). "This association is strongest for working-class boys and boys whose parents have not themselves attended a grammar or independent school, and less strong for middle-class boys and boys with a parent who has attended a selective school" (Holmes and Croll 1989 p44).

It is not possible to talk of causality here. "Success at school may predispose a pupil to spend time working on homework, just as time spent on homework may help in promoting achievement. It is also possible that other variables may be responsible for variations both in achievement and in homework time" (Holmes and Croll 1989 p44).

There was some consideration of other factors in the analysis, like socio-economic status, weekly television viewing, and part-time employment.

The time spent on homework was self-reported, though parents were required to sign the child's homework diary.

No information was given on the nature of the homework, or the marks achieved by the boys. The length of time on housework expected by the school policy was arbitrary - why not more or less?

Though the outcome measure of school examination marks was more objective than self-reports, there were no details about the standards.

The sample was relatively small, and involved boys (at a grammar school) already showing educational success (ie: not a cross-section of all abilities).

2. Tymms and Fitz-Gibbon (1992)

Tymms and Fitz-Gibbon (1992) found that 17-18 year-old students doing more homework obtained better grades in national examinations ("A" levels) to some extent. The researchers analysed data collected in 1989 from around 3000 individuals in north-east England.

Tymms and Fitz-Gibbon (1992) stated: "The averages indicate a fairly modest payoff for hard work. Students who worked for more than 7 hrs a week for one A-level tended to get a third of a grade better than students of the same gender and ability who worked less than 2 hrs a week, and if students with similar prior achievement are considered, the advantage only amounted to about a fifth of a grade" (pp7-8).

This was analysis based on individuals, whereas "as far as classes were concerned, in those where much homework was reported, the A-level grades, having been controlled for individual cognitive measures and hours spent on homework, were no better than those in which little homework was reported. In other words, for two pupils doing the same amount of homework and with the same prior achievement or ability score but in two different classes, one where the student generally did a lot of homework and one where the student generally did little homework, there was no difference between their final A-level grades" (Tymms and Fitz-Gibbon 1992 p8).

Tymms and Fitz-Gibbon (1992) offered this thought on the findings: "when considering the value of homework it is worth bearing in mind two competing possibilities. The first is that more work brings more achievement, and the second is that more work can simply be a reflection of a worried state of mind and that it can add to the student's concern and in the long term be counter-productive" (p8).

The data on amount of homework were self-reported.

APPENDIX 2B - BIAS EVALUATIONS

Rational theories of decision-making assume that the individual makes use of optimisation - ie: chooses the option with the maximum benefits and minimum costs. Non-rational theories propose that decisions are based on "good enough" or "aspiration level" (ie: an outcome that the individual is happy with). Non-rational theories take account of emotions in decision-making, as well as social heuristics (eg: "eat what other conspecifics eat") (Gigerenzer 2001).

O'Connor and Cheema (2018) outlined a bias in decision-making where "the process of repeated evaluations leads to increased experiences of processing fluency and, ultimately, an inflation of evaluations that come later in a sequence" (p779). Put simply, evaluations are more positive for later "candidates".

O'Connor and Cheema (2018) described this bias as a form of misattribution. So, "as the evaluation process becomes more fluent, experiences of cognitive ease about the evaluation process will be misattributed to the content of the target itself" (O'Connor and Cheema 2018 p780). These researchers showed this process in four studies.

Study 1 (analysis of secondary data) - An analysis of the judges' scores over twenty seasons of the TV reality show, "Dancing with the Stars". Scores given to contestants later in the season were significantly higher than those earlier (even controlling for improvements of dancers over time, and more skilled dancers later in the season) (mean: 8.18 vs 7.87 out of ten). "Overall, these data suggest that as judges on 'Dancing With the Stars' grow more accustomed to judging contestants, they evaluate them more favourably" (O'Connor and Cheema 2018 p782).

Study 2 (analysis of secondary data) - Grades from all courses at a US university between 2000 and 2009 were analysed (n = 1854). A comparison was made between the first running of a course and the subsequent occasions, and it was found that average grades were higher as time passed. The analysis controlled for lecturer's improvement that led to better student performance, and student improvements over time.

Study 3 (laboratory experiment) - 168 student participants rated ten short stories from 1 to 7 at a rate of one story per day for two weeks. The order of the stories was randomised between students. The score of the first story was compared to the score of the tenth story. The tenth story was rated significantly more positively on average than the first one.

At the end of the process, the students were asked if rating was easier than at the beginning, and whether they had become more positive over time. The participants agreed with the former, but not with the latter. "In other words, participants in hindsight reported increased experiences of ease as they rated more stories, but they remained unaware that increases in order or felt ease would lead to more positive evaluations" (O'Connor and Cheema 2018 p785).

Study 4 (online experiment) - 362 participants recruited from Amazon Mechanical Turk completed a version of Study 3, but with an added difference. As part of the rating of each story, participants either wrote a few sentences to explain their decision (simple elaboration condition) or more details about their decision (complex elaboration condition). The ratings became more positive with time, irrelevant of the elaboration used.

O'Connor and Cheema (2018) concluded: "Our findings unmask an unsuspected culprit embedded in every corner of daily life from the trivial to the life altering: that the decision process itself might contaminate people's evaluations as they become more experienced with it" (p789).

But they admitted: "While we cannot be certain of all external influences on such evaluations, we took particular care to rule out or control for several plausible alternative explanations. Even when we controlled for these and other factors, the effect of order persisted in all studies, and importantly, we documented that perceived fluency, directly assessed after each evaluation, mediates this effect" (O'Connor and Cheema 2018 p788).

REFERENCES

Cooper, H (1989) Homework White Plains, NY: Longman

Cooper, H et al (2006) Does homework improve academic achievement? A synthesis of research, 1987-2003 Review of Educational Research 76, 1-62

Corno, L (1996) Homework is a complicated thing Educational Researcher 25, 8, 27-30

De Jong et al (2000) Homework and student math achievement in junior high schools Educational Research and Evaluation 6, 130-157

Fan, H et al (2017) Homework and students' achievement in math and science: A 30-year meta-analysis, 1986-2015 Educational Research Review 20, 35-54

Fernandez-Alonso, R et al (2015) Adolescents' homework performance in mathematics and science: Personal factors and teaching practices Journal of Educational Psychology 107, 1075-1085

Gigerenzer, G (2001) Decision making: Non-rational theories. In Smelser, N.J & Blates, B (eds) International Encyclopaedia of the Social and

Behavioural Sciences vol 5 Oxford: Elsevier Science

Hartley, J (1999) Is homework good for you? Psychology Review September, 26-29

Holmes, M & Croll, P (1989) Time spent on homework and academic achievement Educational Researcher 31, 1, 36-45

House, J.D (2000) Relationship between instructional activities and science achievement of adolescent students in Hong Kong: Findings from the third international mathematics and science study (TIMSS) International Journal of Instructional Media 27, 275-288

House, J.D (2002) Relationship between instructional activities and science achievement of adolescent students in Japan: Findings from the third international mathematics and science study (TIMSS) International Journal of Instructional Media 29, 275-288

O'Connor, K & Cheema, A (2018) Do evaluations rise with experience? Psychological Science 29, 5, 779-790

Tymms, P.B & Fitz-Gibbon, C.T (1992) The relationship of homework to A-level results Educational Researcher 34, 1, 3-10

3. DESISTANCE FROM CRIME

Desistance from crime for individuals with a history of offending includes social/structural factors like stable employment and intimate relationships, and identity change ("imagined future selves"; Giordano et al 2002). So, "the rehabilitation process involves at some level the need to develop a new story for oneself that can explain one's past and give a convincing account of why the person is no longer like that anymore" (McAlinden et al 2017 p268).

"However, the majority of major research studies in desistance have either explicitly excluded or else implicitly neglected cases of individuals convicted of sexual offending from these analyses. As such, it is unclear whether the theories that have been developed to account for desistance actually apply to the topic of desistance from sex offending or if desistance is an entirely different process for this particular offender group" (McAlinden et al 2017 p267).

McAlinden et al (2017) explored this issue with an interview study of thirty-two individuals convicted of child sexual offences in England and Wales. Twenty-five of the sample had been living in the community for at least five years without offending ("A group"), and the others had reoffended within the last year ("B group").

The researchers outlined the findings under three headings:

i) Work identities - Having a career or a series of jobs was described as a "high point" for members of the "A group". Comments included: "I love my work [...] It keeps me very busy, it gives me a lot of pleasure and the end product when I know it's been good then I suppose it gives me quite a buzz"(interviewee A3), and "work will give you something to get up in the morning for" (A1)(p272).

Beyond the obvious benefits of financial reward, work gave satisfaction and relationships, and, as interviewee A7 observed, "If you're working you keep out of trouble, you keep yourself occupied" (p272).

Individuals in the "B group" had a slightly different experience, as summed up by B1: "I tried many things... I think I just sort of like drifted through life for a bit" (p272).

ii) Relationships - Along with work, Giordano et al (2002) referred to new and meaningful relationships as the "respectability package".

The importance of relationships for desistance was ambiguous (compared to non-sexual offenders) with some

interviewees reporting the love of a partner, for example, as key (eg: "I thought I've been a fool, I could've lost her, you know, if anything had have happened, if it had of gone further, I could have lost her after all this time. And that brought me to my senses"; A12; p275).

But "the narrative of 'settling down' into a relationship as a means of transitioning out of a pattern of criminal involvement was largely absent from the interviews" (McAlinden et al 2017 p274).

iii) Future selves - Work and relationships were important in relation to future aspirations - eg: "In the future I hope to be happy, erm, offence free [...] I would like to eventually get into a relationship [...] I'd just like to be happy with good friends around me, family, good job" (A18; p277).

These interviews showed that desistance from sexual offending depended on the social/structural factors seen in relation to other offenders, and McAlinden et al (2017) commented that "the agentic willingness to change on the part of individuals like those in this sample needs to be accompanied by credible social opportunities for change and a range of external situational supports to help sex offenders achieve meaningful lives" (p278).

Many of the offenders referred to the shame about their behaviour, and escaping the stigma associated with it. Lageson and Maruna (2018) described the Internet as a "digital prison" where escaping from past crimes and labels is difficult. For example, in the USA, Freedom of Information laws and First Amendment protection allows the posting of police records and court documents. "This digital trail documents any and all contact with the justice system (not only convictions), spreading easily found labels that are difficult to ever remove" (Lageson and Maruna 2018 p118).

Lageson and Maruna (2018) analysed 82 citizen-run crime websites or social media sites in the USA. The websites used "stereotypical depictions of criminals", including gangsters, thugs, drug addicts, and welfare recipients. Arrest mugshots were offered to be commented on, and details of full name, date of birth, and home address, for instance, were available.

The motivation of some websites can be summed up in the phrase: "we cannot let some thugs make us afraid", and in this example: "This defendant has shown NO remorse. She is vicious and she is devious. She planned this crime meticulously. She stalked him. She cornered him. She shot him. She stabbed him. She covered up her crime. She lied. And after all of the above, she was found GUILTY of murder in the first degree with heinous and cruel circumstances. This creature does not deserve

to take another breath" (p121).

Lageson and Maruna (2018) summed up: "Dominant patterns of discourse portray crime as a persistent social issue and reflect serious scepticism of the modern state to adequately control crime. In an effort to take control, website users assign blame to a particular class of people and provide powerful commentary that entrenches stigma. Developing and posting crime commentary appears to constitute an expressive symbolic ritual that may help people work out their mixed views on impenetrable social issues" (p123).

Lageson and Maruna (2018) also interviewed twenty-seven individuals and six attorneys in the USA attempting to expunge past information from these websites. "Sharon", for instance, described the situation: "If I Google myself it'll say I have a criminal history, but it won't say what it is unless I pay. So I never pay. But they do have some that come up and show your criminal history and it's not accurate, because if something is dismissed, it doesn't say it's dismissed" (p124).

The accuracy (or more correctly, the inaccuracy) of the online material was an issue, as "Jamal" described on one person's website: "A lot of people are getting offended. I've never been on [his website] or anything like that, but people I know have been on there and they really, really is mad about it. He's out there exposing them and staying stuff he is not supposed to say. Hurtful stuff. He don't even really know if this was a conviction or what it may be. He's hurting all these people's feelings about stuff and he doesn't know the facts" (p125).

Lageson and Maruna (2018) outlined two consequences of the "digital footprint". Firstly, offences from many years ago are linked to individuals now, and secondly, "the omnipresent threat of exposure could shape behaviour in ways that have an indirect criminogenic effect. After all, one way to avoid having one's criminal record exposed in this way is to avoid interacting with institutions or initiating new roles or relationships that might warrant a basic internet search. This would mean, however, avoiding precisely the sorts of involvements (education, employment, military service, new relationships) that research suggests support desistance efforts" (p126).

REFERENCES

Giordano, P.C et al (2002) Gender, crime and desistance: Toward a theory of cognitive transformation American Journal of Sociology 107, 4, 990-1064

Lageson, S.E & Maruna, S (2018) Digital degradation: Stigma management in the Internet age Punishment and Society 20, 1, 113-133

McAlinden, M-A et al (2017) Desistance from sexual offending: Do the mainstream theories apply? Criminology and Criminal Justice 17, 3, 266-283