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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.

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1. WATER SECURITY IN AFRICA

1.1. OVERVIEW

Isaacman and Musemwa (2021) began with a solemn observation: "Water is both a pre-requisite for all life and is crucial to economic and social transformations and stable societies [1]. Neither the human nor the natural world can survive without water. Yet there are increasing concerns among scholars, state officials, and development experts about the alarming misuse of water, which has resulted in almost every major river being dammed and diverted, millions of people denied regular and equitable access to clean drinking water, a rise in water-borne diseases, and unpredictable flooding" (p7). Conflict of water resources is a possibility, and global climate change has exacerbated the situation.

"A water crisis sparked by climate change is threatening one-quarter of humanity" (Isaacman and Musemwa 2021 p9). Climate change will manifest particularly as rising temperatures and changing rainfall patterns, and individuals will experience the changes as droughts and the drying up of rivers and lakes at one extreme, and flooding at the other.

Introducing the topic of water security in Africa, Isaacman and Musemwa (2021) outlined four critical dimensions:

i) Increasing scarcity, privatisation, and commodification of water in urban areas - Many African countries "have had to contend with the contradictions inherent in the International Monetary Fund's and the World Bank's neo-liberal reforms. In response to these policies, several governments significantly reworked the legal and policy fields in the water sector to create conditions for market-propelled and donor-driven water

[1] Godrej (2022) observed: "Anyone who has witnessed the communion of all forms of life at the river bank, in nature documentary or first-hand, will realise why the function of rivers can best be described as 'life support'" (p16). Only about 0.3% of water on Earth is surface freshwater (rivers, lakes and swamps) (and thus usable by humans and other species), but over 140 000 different species make use of it (Godrej 2022).

privatisation. Unsurprisingly, privatisation and cost recovery have been received with contestation and protest, as they have been abysmally unsuccessful in providing low-income and poor residents with sufficient water supply services within their means. Clearly, the market-determined reforms within the water supply domain became one of the critical factors that helped create patterns of unequal access to water" (Isaacman and Musemwa 2021 p11).

ii) The impact of large dams on the surrounding countryside - The construction of "even bigger hydro-infra-structure" (Isaacman and Musemwa 2021 p12) has been seen as a good strategy to deal with rainfall variability, and such projects are supported by international finance. But the construction of large dams often means the flooding of acres of fertile farmland, and the uprooting of local people (eg: 120 000 people in Egypt and Sudan from the construction of the Aswan Dam; Isaacman and Musemwa 2021).

Communities downriver from dams also face negative consequences, and there is the risk of dam collapse in the future (Isaacman and Musemwa 2021).

Elsewhere, Mulligan et al (2022) outlined a database called "Global Dam Watch knowledge-base" (GDWkb) to help to evaluate dams and their impact. "Dams are one of the most pervasive geo-engineering accomplishments globally, with the largest dams totalling around 58,000 worldwide, the majority of which have been built within the last 60 years" (Mulligan et al 2022 p2).

Dams support around 15% of global food production through irrigation, and provide 70% of renewable energy production (Mulligan et al 2022).

iii) The health consequences of water shortages, and the subsequent impact on other aspects of life - The use of contaminated water is a risk, and "a wide array of water-borne illnesses persist, including cholera and typhoid. They disproportionately affect the most vulnerable urban residents: babies, the elderly, and the destitute. The commodification of water has simply highlighted the sharp economic divides between those who can purchase bottled water and those who cannot" (Isaacman and Musemwa 2021 p17).

iv) The "politics of water" - Water scarcity "does not inevitably produce crisis... [but] embedded in crises of water are crises of power relations: 'flows of water

are also flows of power' [Mehta 2005]" (Isaacman and Musemwa 2021 p11).

Around 60% of freshwater in the world is trans-boundary, and so the potential for conflict and/or co-operation is high. For example, the recently built Grand Ethiopian Renaissance Dam on the Blue Nile impacts the downstream neighbours of Sudan and Egypt (Banton-Heath 2022).

Banton-Heath (2022) commented that "the question of 'who gets what?', rather than being one of natural justice or moral obligation, is all too often dictated by the political and economic motivations of powerful riparian states. Co-operation in the form of treaties and formal agreements may indeed serve to avoid violent conflict, but unless they are implemented and enforced on equal terms, the word rivalry will remain true to its meaning" (p36).

1.2. SPECIAL ISSUE

The special issue of "Daedalus" (150, 4, 2021) presented different examples of how individuals cope with lack of water on the African continent:

1. Dar es Salaam, Tanzania, and "multiple-sourcing".

Where there is water shortage, scarcity, and unreliability of supply, individuals employ strategies "to ensure sufficient water to survive, if not thrive" (Bender 2021 p49).

One recent strategy in Dar es Saleem is private vending. Historically, with a lack of public water supply, urban dwellers have used boreholes, and cisterns for rainfall, as well as "multiple-sourcing" (ie: both naturally occurring and human sources) (Bender 2021).

Women are the traditional managers and fetchers of household water, while private vending has introduced home delivery by hand, cart, bicycle, or tanker truck. Such water, however, is expensive, and may be as much as thirty times higher than water from a piped connection (Bender 2021).

This also limits the availability to poorer households. It has been estimated that the average consumption of water in lower-income neighbourhoods in the city is 29 litres per person per day compared to 166 litres in wealthy areas (Bender 2021).

"Low rates of consumption, in turn, contribute to

other problems. According to the World Health Organisation, between 50 and 100 litres of water per person per day are required to ensure that basic needs are met. Many neighbourhoods in Dar average well below this, with implications for hygiene and sanitation such as infrequent bathing and cleaning. This exacerbates the health risks already inherent in private water. Most vendors are unregulated, and many procure water from wells that are not registered or tested for quality. Given the lack of improved sanitation or sewerage in most neighbourhoods, many water sources are prone to contamination, especially during the rainy seasons, when floodwaters often over-run poorly protected sources. This raises the potential for disease outbreaks" (Bender 2021 p56).

Bender (2021) saw the "biggest drawback to private vending" was that "it represents the commodification of a basic human right" (p56). Saying all that, private water vending "has become a cornerstone of Dar es Salaam's multiple-source water economy" (Bender 2021 p56).

Climate change will make the situation worse in the future. Any attempt to build infrastructure to bring water from the countryside will be hampered by the predicted more intense dry periods. Bender (2021) recommended building on the creative adaptation of multiple-sourcing in Dar es Salaam. "For over one hundred years, the city has grown and expanded despite the lack of adequate public services, largely through the adaptability, initiative, and dynamism of its people. The need for water, a necessity of life, exemplifies the extent to which communities thrived against the odds. Urban dwellers built a dynamic, thriving urban life without the benefit of the expansive, formal water infrastructures common in the cities of the Global North" (Bender 2021 p60).

2. Damming the Nile and health consequences in Egypt.

In the 1930s it was estimated that over half of Egypt's population was infected with the parasites that cause schistosomiasis, and this epidemic had its roots in the dammed Nile River (Derr 2021).

The Khazan Aswan ("Aswan Low Dam" [2]) was completed in 1902, and that "the parasites that cause schistosomiasis thrive in the ecologies of dammed rivers was a lesson learned first in Egypt" (Derr 2021 p144). The damming allowed irrigation of land, but the "water that filled

[2] As compared to the Aswan High Dam began in 1960 (Derr 2021).

irrigation canals and drains was teeming with life. In addition to human beings, the Schistosoma haematobium and Schistosoma mansoni parasites that cause schistosomiasis thrived in the slow-moving freshwater. So did the two species of tiny freshwater snails, Biomphalaria alexandrina and Bulinus truncatus, that serve as the parasites' intermediate hosts" (Derr 2021 pp146-147). Other parasites also thrived in the newly irrigated soil (eg: that cause hookworm) (Derr 2021).

Derr (2021) commented: "If there are lessons to be learned, it is the intractable relationship of human and environment health and the persistent influence of social and economic structures in shaping these terms. History accretes in the body. On global as well as local scales, this accretion is structural as much as it is environmental. A narrow interpretation of Egypt's twentieth-century history would read the historical relationship between dams and disease as a specific warning. But a dam or any piece of environmental infra-structure is not a thing apart but rather a part of a complex human/non-human environment and a system of global power structures" (p154).

This has implications when faced with climate change. So, Derr (2021) asserted, "if our solutions to climate change imagine an environment that is analytically and materially distinct from human bodies, we will continue to be surprised, sometimes horrified, by the costs borne by these bodies, especially the most vulnerable among them" (p154).

3. Financing Dams

One of the motivations of large dams is hydro-electric power (HEP), but concerns about the impact of the dam building has led to less international finance available in recent years from the World Bank, say. This reduction has been overcome by Chinese funding in particular (Hwang 2021).

"This influx of Chinese financing raised concerns, ranging from debt sustainability and governance to social and environmental regulations of the projects financed or contracted to Chinese actors" (Hwang 2021 p196). Analyses of the projects have suggested benefits in the main (table 1.1) (Hwang 2021). However, "{A} key emerging observation is that much of the impact of Chinese finance and contracting is dependent on the host country's agency and capabilities" (Hwang 2021 p199).

PROJECT	STUDY	COMMENT
Bui Dam, Ghana	Tang & Shen (2020)	"improved local urban households' access to electricity and increased their ownership of electric appliances" (Hwang 2021 p199).
Merowe Dam, Sudan	Verhoeven (2015)	Keeping the government in power, and "long-term economic sustainability and environmental and social impact all took a backseat" (Hwang 2021 p199).
Generally	Hwang (2021)	• Growth in trade and construction sectors. • Piped water to households. • Cost of debt repayment.

Table 1.1 - Selected studies of Chinese-financed HEP projects.

4. Everyday Experiences in Accra, Ghana

"At least half of Accra's residents do not enjoy safe, secure, and affordable access to water on a regular basis" (Harris 2021 p64). Safe water means that there are not health risks associated with using it, while secure refers to delivery in an appropriate and reliable manner, as well as, of course, affordable to households. For example, it has been estimated that some households spent between 60 to 90% of their total income on water (Harris 2021).

The problem of water insecurity is "already part of the lived reality" of individuals and not a new consequence of climate change, though the situation will be exacerbated by climate change (Harris 2021).

Harris (2021) explored the everyday experiences of water insecurity in Accra. In one area on the outskirts of the city, for example, "several residents noted that they would be 'free' and 'free from suffering' if they could have better access to water" (Harris 2021 p72). This area did not have piped connections, and there was a "daily 'chase' for water" (Harris 2021 p72).

Water insecurity was reported as stressful, as well as potential associated conflicts. Individuals "might wait for water for up to eight hours or more, and that conflict often broke out in such line-ups" (Harris 2021 p73). Even with piped water there is the potential for conflict over bills to residential compounds. One local leader said: "in most compound houses there were conflicts on water management so they disconnect and they buy outside... people prefer buying from vendors so they have their peace" (quoted in Harris 2021). The counter-

intuitive result is that communities with piped infra-structure may be "more vulnerable and less resilient to acute water shortages" (Harris 2021 p74) than communities without the infra-structure.

Community involvement was also influenced by water access - for example, as it improved "residents were less likely to be involved in the community" (Harris 2021 p74). Taking it further, "trust in government was also positively correlated with community engagement" (Harris 2021 p74).

Harris (2021) ended: "Attending more adequately to the social, contextual, and everyday dimensions of water insecurity shows that relationships, norms, and other practices are of critical importance" (p77).

5. Impacts of Damming

Whatever the benefits of building dams, there are costs "mainly in the form of the degradation of the donor river systems, a severe decline in species and habitat biodiversity, and impacts on the lives and livelihoods of those depending on healthy rivers. Rivers are living ecosystems that provide a range of services that we all benefit from: delivery of freshwater over vast landscapes; purification of used water; attenuation of floods by storage in floodplains; replenishment of groundwater that in turn supplies river flow in the dry season; stabilisation of banks and coastlines; sequestration of carbon in wetlands, thereby helping to keep the brakes on climate change; and supporting the life stages of a myriad of plants and animals" (King and Brown 2021 pp241-242). For example, a decline in the number of antelopes (from 110 000 in 1973 to 30 000 in 2015) on the Kafue flats, Zambia, after reduced flooding with the building of the Itezhi-Tezhi Dam (King and Brown 2021).

Dam-building to provide water was seen as a laudable project, but King and Brown (2021) asked what has gone wrong, answering that decisions were made based on "a narrow range of economic benefits" (p245). The inclusion of the ecosystem impact into decision-making was being varied as a need by the end of the last century.

King and Brown (2021) considered what we know now compared to half a century ago:

a) Rivers need their "flow regions" (floods and low flows). "An arbitrary single-number minimum-flow release from a dam to keep a river wet is convenient for planning

and design purposes, but there is no evidence that it will support the river ecosystem" (King and Brown 2021 p246).

b) Wide-ranging ecosystem models help to understand the impact of dams on the many species of flora and fauna.

c) Involve all parties affected by damming in the decision-making process.

South Africa has been a "proud trailblazer" since the 1980s in how to manage water resources (King and Brown 2021). The concept of "Building Block Methodology" was introduced in the 1990s. "This was a prescriptive method that recommended amounts of water for river maintenance, but it could not respond to queries of what would happen to different aspects of the river system or to people if those amounts were not provided" (King and Brown 2021 p248). In the 21st century "Downstream Response to Impact Flow Transformations" (DRAFT), an ecosystem model, was used to predict the impacts of changes in river flows. The model uses a list of indicators. "Physical indicators could include, for instance, depth of pools, bank erosion, extent of floodplain inundation, and aspects of water quality. Biological indicators could include individual species, such as tiger fish, fish eagle, elephant and Anopheles mosquitoes; and groups of species,such as floodplain spawning fish, riparian trees, and much more. Social indicators could include household incomes, waterborne diseases, and access to potable water" (King and Brown 2021 p249).

The concept of "Development Space" is one general approach to emerge. "For a river or basin, the Development Space is defined as the difference between current ecological and social conditions in the basin and the furthest level of development-driven degradation of the river found to be acceptable to governments and other stakeholders. Negotiating this end point helps them to identify their 'mark in the sand': the future that they do not wish for" (King and Brown 2021 p250).

Cahora Bassa Dam, Mozambique

Isaacman (2021) described the example of Mozambique as an "African state seemingly wedded to grandiose visions of hydro-development" (Isaacman and Musemwa 2021

p18). In 1974 the Cahora Bassa Dam was completed alongside claims of how life would be transformed for millions. But the impact on the Zambezi valley was negative for humans and nature.

"The free-flowing Zambezi provided sustenance to riverine communities in... important respects. Before Cahora Bassa, approximately sixty species of fish inhabited the river. Elders recalled that the Zambezi provided a large catch, which they consumed. Fish were a major source of protein. The river also attracted large herds of impala, gazelle, elephants, buffalo, and eland from the nearby forests to water on the banks of the Zambezi and adjacent wetlands, where they became prey for skilled hunters. Game was an integral part of the local diet. Peasants also consumed meat in larger amounts at important social occasions and at rituals propitiating the ancestor spirits. All of this changed, however, with the construction of Cahora Bassa" (Isaacman 2021 p107). Over 42 000 locals were forcibly moved, also, to allow construction of the dam (Isaacman 2021).

Downstream wetlands dependent on the previous annual flooding of the Zambezi suffered. Within twenty years "formerly a wide river system with 'open mosaics of marsh, pond, oxbows and shallow wetlands' – had been converted to a system with 'choked wetlands, tree and bullrush encroachment along margins' [Davies 1986], and impoverished marshlands. The overall result is less diverse, less productive riverine ecosystems" (Isaacman 2021 p113). Impacts have occurred even to the mouth of the river (nearly 500 kms away) (eg: on the coastal shrimp industry) (Isaacman 2021).

Into the 21st century and the Mozambique government showed interest in the construction of another dam on the Zambezi. Many of the claims made previously were recycled (eg: electricity and economic development for all). Yet only 30% of the population have power from Cahora Bassa, and many of them cannot afford the electricity (Isaacman 2021). The fate of the new project is uncertain as funding is a crucial issue (Isaacman 2021).

Isaacman (2021) ended: "Climate change has further subverted the planners' original prediction that the dam would be a powerful weapon to increase irrigation and agricultural production. Instead, it has intensified hazardous conditions for the inhabitants of the river valley. Between 1960 and 2006, average annual rainfall has decreased at a rate of 3 percent per decade, but the proportion of rain falling in heavy rain years has increased by a similar amount. The results have been longer periods of drought and shorter, but more intense,

rainfall leading to recurring droughts and periodic massive flooding, soil erosion, food shortages, and disease. Every decade since the construction of the dam has seen massive floods, displacing thousands of households and inundating much of the most valuable farmlands" (p118).

Akosombo Dam, Ghana

The promoters of dams have used different arguments. For example, in Ghana, the Akosombo Dam (completed in 1965) was promoted as a generator of electricity and thus industrialisation of the country, while the Pwalugu Dam (being planned) is presented as solving water shortages for local farmers (Miescher 2021).

The Akosombo Dam created the Volta Lake (over 3200 square miles in size), which displaced 80 000 people. The government claimed the movement of people was "orderly and well-organised", but Miescher's (2022) local interviewees found it "traumatic and often chaotic" (p129).

Miescher (2021) gave a snapshot of the experience: "People shared haunting images about the displacement. Resident Janet Obenewaa recalled joining a canoe after the flooding. When paddling to the site of Worobong, they could only recognise the tips of coconut palms rising from the town. Everything else had been submerged. Yet surveying the water, to their horror, they noticed floating caskets washed out from their graves, as well as antelopes, grasscutters, and snakes desperately trying to reach the shore. Since the settlers had lost their crops, the World Food Programme agreed to feed them with food that was strange to them, like yellow corn, corned beef, and luncheon meat. 'It was a sad story', Fosuaa recalled. 'Some people cried until their eyes turned red'. Men drowned their sorrows in alcohol" (p129).

Resettlement towns (eg: Amate) did not provide the promised services. "Access to clean drinking water and sufficient farmland remained perennial issues" (Miescher 2021 p130). Many people left these towns (eg: 60% by 1968; Afriye and Butcher 1971). "These days, Amate, with its large number of abandoned houses and poverty, resembles a ghost town. Many core houses remain unfinished. These abandoned and incomplete houses, according to anthropologist Thomas Yarrow [2017], are a reminder of the 'unrealised possibilities and promises' of modernisation in resettlement towns. They provide vivid evidence of a future that might have been"

(Miescher 2021 p130).

Put simply, the "anticipated modernisation did not happen" (Miescher 2021 p136). Miescher (2021) ended with the hope "that the shortcomings of Akosombo will not be repeated" (p137) with the Pwalugu Dam.

6. Health and Urban Water

Urban Africans are forced to use contaminated water because of water scarcity. Cholera, for instance, is one of the health consequences (eg: 29 000 cases in Accra, Ghana, in an outbreak in 2014; Livingston 2021). The source of cholera is "unhygienic and unclean" water contaminated by sewage (Livingston 2021).

"Water is a primary human need, yet it can carry microbial pathogens like cholera, typhoid, or E. coli, or be contaminated with pesticides, heavy metals, industrial chemicals, or other toxins, resulting in substantial bodily harm" (Livingston 2021 p87). Buscher and Marcatelli (2019) talked of "liquid violence" to describe the situation where "some people are systematically left without sufficient water" (quoted in Livingston 2021).

But "liquid violence" is not experienced by all in the cities. "In any African city, there are residents with piped water and indoor plumbing, and hotels with swimming pools, as well as people who must queue to collect or purchase water in small quantities for carefully rationed domestic use" (Livingston 2021 p89).

A woman in Lilongwe (an informal urban settlement) in Malawi described her experience: "I wake up very early in the morning, sometimes around 5 am. Because some days I have to wait a long time at the kiosk, for up to 1 hour, before it is my turn to fetch water. Sometimes I wait for that long and I still come home without water because the water stopped flowing or it was time for the water kiosk attendant to close the kiosk" (Adams 2018 quoted in Livingston 2021).

Urban residents get their water from multiple sources, including rainwater cisterns, bottle or sachet (packaged water) [3], and pipes (formal and informal), for instance. For individuals in informal urban settlements in particular, there is an "unstable archipelago of service provision" (Livingston 2021 p93). This leads to difficult decisions as Livingston (2021) outlined: "Imagine having to choose between purchasing clean water or using untreated water from a river or shallow well in

[3] Packaged water is not always safe (eg: Aslan et al 2020 in Ghana), and it produces plastic waste (Livingston 2021).

order to save that money for rent. Imagine caring for children with repeated bouts of acute diarrhea while also having to queue two hours to procure the water necessary to bathe and otherwise clean up after them. Water scarcity threatens hygiene, which carries serious negative health consequences" (p93).

Meanwhile industrial pollution of water is a health threat for the kidneys, for instance (Livingston 2021).

7. Politics of Water

Klug (2021) noted three broad frames - the institutional, the hydrological, and the ideological - in the tension between principle (eg: the right to water) and the reality in South Africa.

Post-apartheid South Africa was focused on principles like "water security for all" in a 1998 Act. But "there was the claim by landowners that any change to water rights would violate their newly enshrined constitutional rights to property" (Klug 2021 p225). Water resource management, thus, existed in such a political environment, and the decisions of official bodies like the Water Review Panel were influenced by it. This included the principle of a "reserve" of water for human domestic use. Where there was conflict, the government would be "the overall manager of water" (Klug 2021).

Today "powerful interests" in the form of mining and agriculture continue "to function in a separate realm" (Klug 2021). The post-apartheid period has seen "model policies and legislation" but with implementation problems (Klug 2021).

Klug (2021) ended: It may be equally the case that the defining of principles of water law and management may not guarantee a more just distribution or access to water for the peoples of South or Southern Africa, however the existence of these principles, whether as policy guidelines, constitutional rights, or in the language of regional and international agreements, provides two important resources for those who struggle for access to water. First, a vision of a more just allocation of this fundamental resource and, second, an articulation of common benchmarks to which states and governments might be held to account" (pp234-235).

Lesotho

Lesotho exports water to South Africa through the Lesotho Highlands Water Project (HWP), which began in 1998 (Mwangi 2021).

"The project, hailed as a major engineering feat – which it is – generates badly needed hard currency and hydro-electricity for Lesotho. But there is another side to this story. The project has precipitated wide-scale environmental damage and human suffering, which proponents of the LHWP have understated or overlooked in the name of development" (Mwangi 2021 p181). The negative consequences include local springs drying up, fewer trees growing for firewood, and burial sites underwater at the dam sites. "Historically, consulting the ancestors was essential to ensure the fertility of land, cattle, and women as well as the health and well-being of the region's rivers. Those whose ancestors' graves were relocated had to travel long distances to pay homage to the deceased" (Mwangi 2021 pp187-188). Displaced communities reported feeling anxious and extremely vulnerable (Thabane 2000) [4].

Climate change will affect (and is already affecting) water deliveries to South Africa (Mwangi 2021).

Zimbabwe

Urban water shortages can be the product of past colonial regimes, as in Harare, Zimbabwe. The structures of water distribution was to benefit Europeans over Africans in the past (when called Rhodesia [5]). But "the post-colonial government failed to fundamentally transform the colonial patterns of urban water distribution and did little to increase water supplies to keep pace with a rapidly growing urban population and a geographically expanding city" (Musemwa 2021 p28).

For example, the northern suburbs in colonial times were the domain of the Europeans, living in large houses with their own swimming pools, and they had clean piped water, while the African shanty townships "relied on very limited communal water taps" (Mudeka 2011 quoted in Musemwa 2021).

[4] There are campaigns to take down dams began in recent years by Indigenous groups around the world. Some campaigns have had success as in four dams on the Klamath River in the USA (Shoemaker 2022). While the United Movement of Mongolian Rivers and Lakes was founded in 2008 to campaign against unregulated mining using high-pressure water systems (Tumurtogoo 2022).

[5] Zimbabwe became independent in 1980 (Musemwa 2021).

One observer in the mid-20th century commented: "The common latrines – which are in use in most urban native locations, townships or compounds – are kept in an extremely insanitary condition, possibly because the habits of many of their users are primitive in the extreme. These communal latrines are a menace to the health of the people and a disgrace to the Colony" (Muyanda 1954 quoted in Musemwa 2021).

In the 21st century Zimbabwe faced a political and economic crisis with "hyper-inflation, an economic meltdown, the government's abuse of human rights against members of the opposition party, and a high unemployment rate, while Robert Mugabe and his party faced increasing international isolation due to, among other things, the violent land reform program that ejected White farmers from their farms" (Musemwa 2021 p40). So, the authorities were not in a position to solve the water infrastructure problems, even if they had wanted to.

Ethiopia

The construction of the Grand Ethiopian Renaissance Dam (GERD) was launched in April 2011, and is the biggest infra-structure project in Africa (Verhoeven 2021a). Verhoeven (2021a) summed up attitudes towards GERD: "To Ethiopia's political leadership and its bureaucratic-scientific apparatus, the country's intractable poverty and international marginalisation are a direct result of a failure to harness its hydro-potential and build the dams, reservoirs, and irrigation systems required to actualise its water tower destiny [6]. However, to millions of people living downstream, rhetoric of the GERD as the anchorage of a resurgent Ethiopia that determines the flow of the river instils existential concerns about their own water and food security" (p160).

Those living downstream are also in Egypt. So, there is the potential for conflict between the nations. This is not helped when the "standard narrative posits that Ethiopia was made to suffer because of the 'historical injustice' of 'colonial treaties' that reserved the lion's share of waters for the downstream riparians Egypt and Sudan (often described as Arab in this context) at the expense of the 'starving' upstream countries (described as African); the injustice continues to this day because international financial institutions and local and global allies of Cairo have thwarted Ethiopia

[6] Ethiopia is described as "Africa's water tower" because of the high level of rainfall in the central, northern, and southern Highlands (Verhoeven 2021a).

from getting access to finance, expertise, or legal recourse to change the unfair status quo" (Verhoeven 2021a p169).

Critics within Ethiopia, however, have rejected this narrative. The "project has intensified internal conflict among the ruling party leadership and fanned ethno-regional differences between the winners and losers of economic development. The project that was supposed to bring all Ethiopians together under a nationalist banner of environmental justice has been weaponised by elites jockeying for power in ways that threaten the survival of Ethiopia" (Isaacman and Musemwa 2021 p19).

1.3. CONCLUSIONS

Providing a concluding overview of the special issue of "Daedalus", Verhoeven (2021b) began with a sad picture: "Africa is at the centre of the global water predicament and climatic upheaval. Africa contains the greatest number of least-developed countries of any continent, the most woeful sanitation infra-structure, and the highest share of people in highly weather-dependent rural employment. It is here that, owing to global warming, crop yields are expected to decline most sharply; sea-level rises along the African littoral are already higher than planetary averages. Africa's pastoralist communities are the biggest on Earth and comprise about one-fifth of its population; weather variability defines the nomadic way of life, offering many rewards but, especially in an age of uncertainty, also existential risks. Increasingly erratic precipitation patterns are especially daunting considering no continent has less reservoir capacity for water storage" (p260).

Without rejecting these concerns, Verhoeven (2021b) wanted to reframe the "problematique". He stated: "In Africa's cities, it might not so much be only the worsening climate that is leading people to be increasingly exposed to a variety of new and old pathogens, but the very policies – cost recovery through water tariffs, new urban zoning laws, and resettlement schemes–adopted in the name of fighting water scarcity and preparing for bad weather" (Verhoeven 2021b p263).

Verhoeven (2021b) also wanted to reject the view of Africans as a "passive victim", and to highlight the "good news". For example, "Africa Rising" is a phrase to describe the economic growth of many countries in the 21st century. "New voices – many of them urban Nigerians,

Kenyans, and Ghanaians, or diaspora returnees – emphasised Africa's entrepreneurial instincts and the possibilities offered by digital advances to leapfrog crumbling infrastructure, a weak state, and resource scarcity by delivering transformational health, commercial, and environmental outcomes. Capitalism and technology can create Africa anew – and for the better" (Verhoeven 2021b p265).

Verhoeven (2021b) concluded that the authors in the special issue of "Daedalus" "have enunciated the pathologies of adopting a view of water security and climate that is devoid of cultural context, history, and social relations" (p271).

1.4. WATER INSECURITY GENERALLY

In London, for instance, the "widespread closure of public toilets and water sources – during a global pandemic, no less, when the prevailing public health advice was to wash your hands well and often – reveals the importance of water-related services as a public good" (Meehan et al 2022 p1). These closures were particularly important for unhoused/homeless individuals. The water, toilet and sanitation insecurity of such individuals is often overlooked (Meehan et al 2022).

"Without a stable home, unhoused people must rely on social infrastructures (eg: shelters and charities) and interpersonal relations (eg: friends and family) to gain access to water, sanitation, and hygiene facilities. Such infrastructures and relations can be precarious, context-specific, and therefore a 'patchwork' solution at best to fulfilling a human right to water" (Meehan et al 2022 pp2-3). There are also the health risks from exposure to unsafe water resources and unclean sanitation facilities (Meehan et al 2022).

Water security is not just a lack of water, but also poor quality (eg: industrial or agricultural pollution) (Manero et al 2022).

Water has value beyond its monetary worth, and one way to value it is "environmental flows" (e-flows). E-flows "describe the quantity, timing, and quality of freshwater flows and levels necessity to sustain aquatic ecosystems, which, in turn, support human cultures, economies, sustainable livelihoods and well-being" (Arthington et al 2018 quoted in Manero et al 2022). For Indigenous peoples, for instance, water can have

spiritual value (Manero et al 2022).

For example, the Kukama people along the Maranon River in Amazonian Peru call the river "ia", meaning "the centre, the life force, the mother - everything" (Boyd 2022 p22). There is a "vibrant spiritual universe" beneath the water as well as the river providing the practicalities of drinking water, fish as food, and a means of transport (Boyd 2022).

Take the Ganges (flowing from the Himalayas to the Bay of Bengal) supporting between 400 - 650 million people, human influence is impacting it, from dams in the upper reaches, and intensive agriculture to pollution (eg: 150 million litres of untreated sewage per day), and 1000 tonnes of flowers offered by religious devotees each day. "And then there are the human ashes and half-burned corpses in their thousands, consigned to the holy waters each day" (Godrej 2022 pp17-18).

Access to water as a human right includes "virtual water", ie: "water that was required to produce the product or raise livestock, but remains invisible. Many countries are dependent on import of food and goods through trade, whereby virtual water 'flows' from one region to another" (Mirumachi et al 2022 p1).

The exporting of "virtual water" can impact the local environment. For example, water used in "industrial farming", which can also degrade the drinking water with chemical fertilisers, as well as lowering groundwater tables (Mirumachi et al 2022).

Mirumachi et al (2022) outlined the consequences: "Growing concerns around water, land and related food scarcity have increased the drive of some countries and actors within countries to appropriate natural resources, chiefly land and water, for their own use. Negative impacts of so-called large-scale land and water grabs disproportionately affect the most vulnerable: women, children, underprivileged and indigenous communities, who often do not hold secure land titles. Similarly, the labour associated with water collection and sanitation in unplumbed areas overwhelmingly falls on women and girls – costs that can be exacerbated by agricultural projects that decrease water availability" (p3).

Mirumachi et al (2022) ended: "Understanding the right to water as more than drinking water lays the groundwork for the sorts of policies that states and businesses must adopt to protect it" (p4).

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2. SUSTAINABLE TRANSPORT AND BEHAVIOURS

2.1 INTRODUCTION

"Sustainable Transport" (SuT) involves "the interplay between technology and psychological factors" (Wang et al 2021 p187), and Wang et al (2021) introduced a special issue of "Transportation Research Part F" (TRF) on the latter. This includes transportation users' travel behaviour, and attitudes to new ideas/technology like

"ride-sharing" and "ride-hailing".

2.2. RIDE-HAILING AND RIDE-SHARING

The "sharing economy" underpins many aspects of SuT [7]. It is based on "sharing under-utilised assets from spaces to skills to stuff for monetary or non-monetary benefits" (Botsman 2013 quoted in Lee and Wong 2021). Technology is central to matching the person sharing with the person needing the object or service.

"Ride-hailing" [8] and "ride-sharing" are prime examples of the "sharing economy". "The term 'ride sharing' originally refers to a phenomenon where a driver gives a person a lift. The driver is an ordinary commuter who has planned the trip, with or without any riders. While 'ride sharing' is [also] a commonly used term to describe people booking a ride that is made available by strangers online..." (Lee and Wong 2021 p14), it is better described as "ride-hailing" or "on-demand ride-hailing" (ODRH) [9].

Lee and Wong (2021) investigated consumer loyalty in ODRH (eg: apps include "Uber", "Lyft", and "Go-Jek") in South-East Asia [10] (appendix 2A). Loyalty was defined as "the extent to which a consumer is intent to provide a particular product or service with his or her exclusive patronage over a sustained period of time" (Lee and Wong 2021 p14). It has two components - "attitudinal loyalty" (the intention to be loyal as seen in recommending the good or service to others), and "behavioural loyalty" (the reflexive or automatic choice) (Lee and Wong 2021). The former includes "psychological attachments" to the business, good or service.

"Word of mouth" (WOM) is an important element of attitudinal loyalty. "In general, positive WOM follows satisfactory service encounters while negative WOM emerges from unsatisfactory

[7] "Shared mobility – the shared use of a vehicle, bicycle, or other mode is – an innovative transportation strategy that enables users to gain short-term access to transportation modes on an as-needed basis" (Shaheen et al 2016 quoted in Wang et al 2022).

[8] Also called "ride-sourcing" or mobility services provided by transportation network companies (TNCs) (Wang et al 2022).

[9] The term "mobility-as-a-service" (MaaS) has also been used. This is defined as "user-centric, sustainable and intelligent mobility management and distribution system. In this system, a MaaS provider brings together offerings of mobility service providers, and provides end-users access to them through a digital interface that allows seamless planning and payment" (Goulding and Kamargianni 2018 quoted in Dzisi et al 2022).

[10] In May 2019 the most popular ride-hailing service in China had over 75 million app users, for example (Liu, Gao and Rau 2022).

encounters" (Lee and Wong 2021 p16).

Lee and Wong (2021) surveyed 277 users of ODRH. The online questionnaire covered nine variables believed to influence WOM, including willingness to embrace innovation (personal innovativeness), environmental consciousness, price consciousness, perceived ease of use, and perceived value (table 2.1).

Variable	Item
Subjective norms	People whose opinions are valued to me would prefer that I should use ride-hailing
Environmental consciousness	It is important to me that the services I use do not harm the environment
Price consciousness	The money saved by finding lower prices is usually worth the time and effort
Perceived safety risk	The possibility of getting duped by the drivers makes me feel unsafe
Perceived privacy security	I am afraid that my personal information will be used in an unwanted manner

(Source: Lee and Wong 2021 appendix A pp28-30)

Table 2.1 - Example of items used by Lee and Wong (2021).

Analysing the data, three types of relationships were found between the variables, and WOM and ODRH:

i) Significantly related as expected - price consciousness, perceived usefulness, perceived ease of use, perceived safety risk, and perceived value.

ii) Not significantly related - personal innovativeness, subjective norms (eg: expectations of others), and perceived privacy security (eg: app user's data).

iii) Significantly related but opposite to predicted - environmental consciousness had a negative relationship with WOM.

Overall, WOM predicted purchase intention.

So, attitudinal loyalty to a ODRH app was positively linked to its perceived usefulness, ease of use, and value, and negatively to perceived safety risk (ie: individuals use the service because they feel safe - low risk). The negative relationship between WOM and

environmental consciousness was a surprise, but it could be that high scorers on this variable would use public transport or a non-motorised means of travel (eg: walking, running, cycling). Ride-hailing is a form of private car usage.

Liu, Gao and Rau (2022) concentrated on perceptions of security: "Over the past five years, a number of incidents of ride-hailing drivers attacking passengers have been reported by major media outlets and attracted notable public attention in China. A famous case was the tragic incident of a female passenger who was sexually assaulted and killed by her ride-hailing driver during a 'hitch' ride in May 2018" (p250).

Perceptions of security may not reflect the actual level of risk, but perceptions of physical risk are key in trust in the drivers and the service (Liu, Gao and Rau 2022).

In the USA, for instance, researchers found that sexual-related attacks occurred in 0.0003% of rides (ie: 3 in 1 million) with Uber in 2017 compared to 0.0005% in China's ride-hailing services and 0.0006% with traditional taxi services in that country in the same year according to official data (Liu, Gao and Rau 2022).

Perceived security is a feeling of safety and includes a general and a situational aspect. The former is a general perception, which is influenced by factors like the probability of a negative event, individual differences in "dread" (fear of a negative outcome), familiarity with the service, and perceived vulnerability. Perception of situational security is specific to a particular occasion/event, and includes factors like the behaviour of the driver, the time of travel (eg: at night), and the condition of the vehicle (Liu, Gao and Rau 2022). These researchers identified twenty-one factors from previous literature.

Liu, Gao and Rau (2022) performed two studies. First, there was a pilot study with a focus group of eleven Chinese ride-hailing users that produced 29 factors influencing perceptions of security.

A questionnaire was subsequently designed and distributed to 163 individuals at a university in China via social media ("WeChat") (Study 1). Factor analysis of the responses to the 29 factors produced four categories:

1. "Platforms' in-built security factors" (eg: the app provides safety guides; the app provides an in-app panic button).

2. "Service type and its space-time features" (eg: travelling at night; travelling to a remote area).

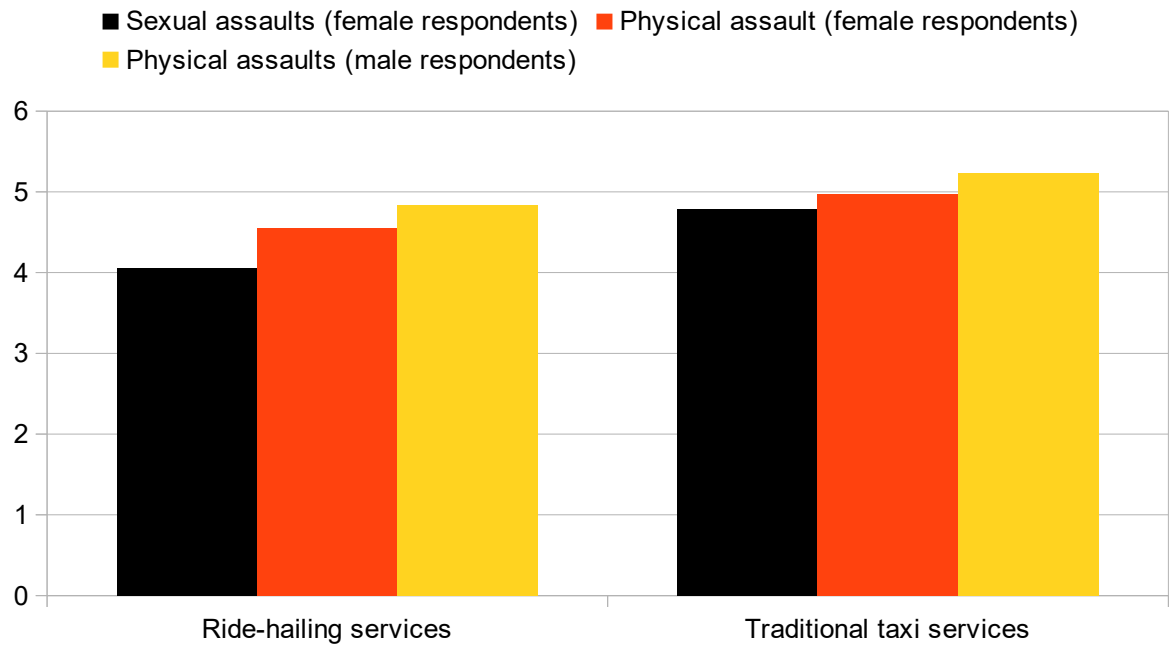
3. "Driver and vehicle" (eg: vehicle is clean inside and outside).

4. "Companion" (eg: travelling with a companion).

The first category received the highest mean score, "which indicates that it might have the strongest positive impact on passengers' security perceptions" (Liu, Gao and Rau 2022 p257).

Study 2 adapted the questionnaire, and had two versions. One version focused on perceived security to sexual assault (completed by 103 individuals), and the other on physical assault (n = 221). Participants also rated their perceptions of security generally and for a specific recent use of the service.

Ride-hailing services were rated significantly lower for the security against both types of assault compared to traditional taxi services (figure 2.1).



(Data from table 5 p258 Liu, Gao and Rau 2022)

Figure 2.1 - Mean scores for perceived general security (out of 7)(where a higher score = perceived as safer).

Generally female respondents rated sexual assault as

a higher risk than physical assault, and as compared to male respondents. Table 2.2 summarises the significant factors for both types of assault and perceived security.

	Perceived General Security	Perceived Situational Security
Sexual Assault	Individual risk attitude. Familiarity with risk. Perceived vulnerability.	Duration of journey. Number of male companions. Perceived reliability of driver and vehicle.
Physical Assault	Familiarity with risk. Perceived vulnerability. Perceived predictability.	Duration of journey. Number of male companions. Perceived reliability of driver and vehicle.

Table 2.2 - Significant factors influencing perceived security.

The relationship between perceived general security and specific situations was weaker for sexual assaults. Liu, Gao and Rau (2022) offered this speculation: "A plausible reason may be that the general perceived security against sexual assaults is lower and that people may take more situation characteristics into consideration, rather than relying on their general belief about the security of the service, when they feel less secure" (p262).

The majority of the respondents were students, and under 35 years old. The frequency of usage of services was not measured.

2.2.1. Minibus Taxis

Dzisi et al (2022) considered minibus taxis in developing countries and their development into MaaS. These are a para-transit mode of transport characterised by "ad hoc route selection, stopping, and operational times" (Dzisi et al 2022 p19). The services are "mainly financed by the informal business sector, with most individual business/vehicle owners owning a small number of vehicles that are typically rented out to drivers. Drivers are as well, expected to render accounts to vehicle owners on a daily, weekly, or monthly basis, after accounting for operational costs of running the vehicle. An agreed proportion of earnings is kept by the driver and shared with the conductor. These arrangements

are as a result, a strong incentive to many operators, who compete aggressively for passengers" (Dzisi et al 2022 p19).

Minibus taxis are, according to Porter et al (2021 quoted in Dzisi et al 2022), "the most dominant mode of transport in most African cities, despite the low levels of customer satisfaction (such as overcrowding, reckless driving, unreliability, and theft) expressed about this mode. Para-transit are also some of the cheapest available modes of transport in most of these areas..., making them the preferred mode of transport for many economically disadvantaged individuals" (Dzisi et al 2022 p19).

Schmidt (2018 quoted in Dzisi et al 2022) outlined four areas for improvement - regulation and enforcement, safety and security, fleet management, and passenger information - and technology (or "intelligent transport solutions" to be exact) could be used. For example, smartphones could provide information, booking, and a "SOS button".

2.2.2. Ride-Hailing Drivers

What about the behaviour of drivers who join an ODRH platform? Studies tend to use GPS records and working schedule information to understand their behaviour (eg: when and how often they work) (Yu et al 2021).

One phenomenon observed is "multi-homing", where drivers "simultaneously register on more than one platform and sequentially provides services on multiple ride-sourcing platforms. Multi-homing ride-sourcing drivers could be motivated by the pricing terms and reduced waiting time for more earnings" (Yu et al 2021 p62).

Yu et al (2021) analysed real-world data on multi-homing from all of the ODRH platforms ("DiDi", "Shouyue", "AA", "Yidao" and "Shenzhou") in Hangzhou, China in December 2017. Some of the platforms tried to regulate platform switching by demanding that drivers must be available for certain hours each day, for example. About a quarter of the drivers in the dataset admitted to registering with more than one platform.

Multi-homing was more common among male drivers, drivers aged 30-40 years old, married, 5-15 years experience of driving, and non-local addresses. The majority of drivers (around 90%) who switched served two platforms, but five was the maximum.

Key factors in switching were income, and work time.

Multi-homing drivers earned a higher average pay-off than single-homing drivers. In the main, this was due to a lower average vehicle vacancy rate and higher total drive time. Switching frequency increased during the evening peak demand hours.

Yu et al (2021) summed up: "Specifically, we find that a lower gap time (ie: the period from the end of the previous order to the next order dispatching) prevents drivers from switching platforms. Thus, to reduce the drivers' switching frequency, platforms should improve their matching process" (p77). The researchers advised the platforms further that "for the drivers receiving orders with a short trip distance or orders to an outlying destination with a low demand rate, platforms should incentivise them with appropriate compensation to reduce their motivation of switching to other platforms" (Yu et al 2021 p77).

There were also differences between high-income and low-income multi-homing drivers. The latter group was influenced to switch by, for example, the gap between orders, while the former by income per hour.

The researchers argued for local authority or government intervention "developing reasonable pricing rules and industry standards for ride-sourcing platforms is vital to prevent malicious competition at a low price" (Yu et al 2021 p77).

This study used real-world data, whereas much other research is based on simulation and modelling, but there was no information on a driver's previous behaviour and long-term patterns.

2.2.3. Car-Pooling

Car-pooling is similar to ride-sharing, though the former has a specific meaning, like a single vehicle shared by commuters (Dinesh et al 2021).

It is important to understand the perceptions of and attitudes towards this behaviour in order to encourage its use. Though there are perceived benefits (eg: environmentally friendly; cost saving), studies report deterrents like perceived risks (eg: lack of flexibility; danger; logistical problems), and a preference for individual car ownership (Dinesh et al 2021).

Exploring the behaviour further, Dinesh et al (2021) recruited four hundred car-poolers at an "IT [information technology] park" in India. A range of questions were asked including about values and beliefs (eg: "I am confident that I could deal efficiently with unexpected

events"; "I like to impress people and want them to admire my choice of transportation"), and perceptions of car-pooling (eg: "I care about nature and believe that car-pooling helps in reducing air pollution"; "I like the concept of car-pooling").

Then the participants read a scenario about a car-pooling service (table 2.3) and responded as to whether to accept or reject the company. The scenario was varied on two dimensions to give four independent groups (table 2.4):

- "You noticed an advertisement of a car-pooling service. The message was given in the following way:
- The idea of carpooling is a simple concept and we (Company X) have taken it to new heights. We are now the leaders in providing car-pooling services across the country. We are working towards providing a sustainable solution to the issue of pollution through the use of less cars on the road. To ensure the safety and security of our riders, we have made KYC {Know Your Customer] mandatory for riders and owners of vehicles. Our service is strictly based on cost-splitting model among the riders. Our riders have access to a lot of cars in their locality. Our riders can experience various types of cars and enjoy the convenience in their city. Be a smart rider and contribute to environmental conservation!" (p186).

Table 2.3 - Sample scenario used by Dinesh et al (2021).

- High PE/High CC - Participants told to reflect on decisions and choose to accept or reject car-pooling company based on what gave them a feeling of control.
- High PE/Low CC - Make a swift decision based on feeling of control.
- Low PE/High CC - Reflect upon decision with no reference to feeling of control.
- Low PE/Low CC - Make a swift decision with no reference to feeling of control.

Table 2.4 - The four response conditions in Dinesh et al (2021).

i) "Cognitive complexity" (CC) - "The psychological characteristics of individuals to engage in complex mental evaluations in taking decisions based on their cognitions" (Dinesh et al 2021 p186). High CC involves

reflections on decisions and outcomes, while low CC leads to swift decisions with limited thought.

ii) "Psychological empowerment" (PE) - This is "the belief of the individual that he or she can understand and control the occurrences in the surrounding social, economic and political environment to aim for and achieve higher levels of goals" (Dinesh et al 2021 p183). High PE is linked to a sense of control while low PE is not.

It was found that CC and PE had significant influences on the motivation to use car-pooling, while values, and perceptions had an indirect impact. In other words, Dinesh et al (2021) explained, "attitude and behaviour towards car-pooling significantly differ among commuters according to their CC and PE levels. We found that commuters with complex cognitive structures are likely to develop stronger attitude and intentions to adopt car-pooling. Similarly, commuters perceiving higher levels of PE will have stronger attitude and intentions to adopt the same" (p191).

This study showed the complexity generally of decisions, though certain psychological factors clearly play an important role. However, other factors, like social connectedness, and environmental awareness, were not measured.

2.3. CAR SHARING

"Car sharing" is another example of the "sharing economy" [11]. In effect it is the renting of a vehicle for a certain period of time by "club" members. "Car share vehicles are usually parked in designated locations (on- or off-street) and members can rent a vehicle for a short or long period (from half an hour to several days)" (Jain et al 2021 p226).

A literature review by Munzel et al (2019) found that cost savings, and convenience were the key motivators to car share use. But most of the studies reviewed used quantitative surveys, and so did not explore what "convenience", for example, means to individuals (Jain et al 2021). In terms of barriers to car share use in previous studies, these included "lack of awareness of car share..., perceptions that operators are unprofessional, insufficient vehicle variety, higher costs than transit, access issues (eg: complicated, impractical and time-consuming) or vehicles not available

[11] Car-sharing dates back as far as as 1948 in Zurich (Krauss et al 2022).

near home" (Jain et al 2021 p228).

Jain et al (2021) performed a qualitative study in urban Melbourne, Australia, with five focus groups and eighteen individuals interviews of car share members, ex-members, and non-members. The researchers drew out the key motivators and barriers from the transcripts, including:

i) Cost savings - eg: A female car share member said: "I'm not in Melbourne all the time. If I owned my own vehicle, it will just sit in the garage and depreciate. Whereas here it's just using the car when I need it so it's so much more cost-effective" (p232).

ii) Convenience - This meant different things including access, and no ownership problems for members, while "car-owning non-members were more likely to refer to car share in terms of reduced convenience. The process of using car share was inconvenient and required too much planning and would decrease their flexibility or ability to be spontaneous. A non-member explained how the pre-booking and anxiety related to booking duration made car share feel less convenient than car ownership" (Jain et al 2021 p233).

iii) Environment - A female care share member said: "One thing that stuck in my head that I read about a few years ago, was the three most damaging things you can do in your lifetime for the environment and one of the top three was owning a car. That never left my mind, and at any point, if I cannot own one, then I will" (p233).

iv) Being part of a community - eg: A male member said: "I am really interested in that sense of community... I used to live in a big apartment block on St Kilda Road, and there were 400–500 people in it... The vast majority of people you didn't see... [when using a private car]... with car share you got to be part of that group of cool people, who got to know each other by not owning a car" (p234).

v) Technology and variety - "The opportunity to use the latest technology to access a (fleet-based) shared car was exciting for some users, for example, one member was 'mind-blown how I could unlock the car with a card'... Most car share users appreciated that the system allowed them to use new, recent car models that were usually better than cars they could afford to purchase" (Jain et al 2021 p234).

vi) Health - eg: owning a private car might encourage its use rather than walking.

vii) Minimising possessions - eg: "you want to reduce what you have" (male member; p235).

viii) "Personal space" - eg: A female non-member said: "If I get into a shared car and it had used cups and all, I wouldn't know what to do. My car is my space and I keep all my stuff in it. How would I do that in a shared car?" (p235).

ix) Key barriers - Access to a car share club/scheme, children, availability of a vehicle when needed, practical difficulties like low fuel or "travel plan fatigue". An ex-member summed up the latter: "My wife is just sick of all the planning around using car share. It was a relief to her when we finally bought that car" (p237).

Social status/stigma was also mentioned, as by a female member: "I also think that there's a stigma around people, who use car share, oh they can't afford to buy a car or that's kind of the vibe I get" (p238).

Jain et al (2021) summarised the barriers in terms of a series of stages to car share adoption:

a) Lack of awareness of such schemes, and/or if nearby.

b) Not interested, though aware - eg: "already own a car" (p239).

c) Active interest - Key barriers here were car share perceived as expensive, concerns about availability of vehicle when needed, and having to return the car to the same location.

d) Discontinuation after trying - "This was primarily due to two reasons: 1) some ex-members only needed car share for a very specific reason at a point of time (eg: moving van). As a car owner, they did not feel the need to continue their car share membership. 2) due to poor initial experience some members found car share difficult to use (e.g. taking photos of the shared car before and after use, miscommunication with car owner)" (Jain et al 2021 p239).

e) Discontinuation after extended use - Due to life

events, like moving to an area with no car share scheme, family pressure to buy a private car, or birth of a child.

Motivations can be categorised as instrumental or functional (eg: practical considerations), and affective and symbolic (eg: how the individual feelings) (Steg 2005). The motivations to use care share and the motivations not to included both categories. For example, "while cost and convenience were the main hook, environmental benefits of car share gave the users a 'warm glow'..." (Jain et al 2021 p240).

Norms were also important on both sides. "Many car share members felt coerced by family and friends to purchase a private car and discontinue car sharing. Family expectations were magnified around times of family formation, where even some proud non-car-owners buckled under family pressure and bought a private car. Some car share members revealed how friends living in the inner city were aware of car share and understood their choice to use car share instead of owning a private car. However, family and friends living in outer parts of the city were less convinced. It is likely that as car share grows in scale and more people use the system, acceptability will also increase" (Jain et al 2021 pp241-242).

Jain et al (2021) emphasised in conclusion that "car share adoption is not a single, binary decision. Instead it is a process... with barriers that vary from stage to stage" (p242).

2.3.1. Ride Pooling

This is a variation of car sharing specific to taxis. The success of car sharing and ride pooling depend on each rider tolerating delays and detours to accommodate the other riders. Heterogeneous rider preferences can influence the success of car sharing and ride pooling. In other words, some riders prefer to take a taxi alone and go directly to their destination, while others are happy to share with riders with different destinations. The satisfaction of preference depends on the availability of taxis, for instance.

Lokhandwala and Cai (2020) simulated the different rider preferences using New York City taxi data from 2016. Not surprisingly, the number of taxi journeys (and hence CO^2 omissions) would be reduced most if all riders are open to pooling, and with a majority preferring ride

pooling to travelling alone. So, incentives will be needed to change the behaviour of individuals who want to travel by taxi alone.

2.4. BIKE SHARING

"Bike-sharing" is a sustainable and healthy option for short trips [12]. It "helps to solve the first-and-last-mile problem by providing seamless connections between various transportation modes" (Chang et al 2020 p82).

Traditional "station-based bike sharing" (SBBS) requires the bike to be returned to specific places, while "free-floating bike sharing" (FFBS) is "a new generation of bike sharing, in which bikes can be parked at any valid places" (Wang and Wang 2021 p54).

One issue with FFBS is the "imbalance problem". "For instance, during morning rush hours, most bike sharing users ride from home to office. Such one-way rides result in uneven distribution, and later users attend [sic] to borrow bikes around the residential area may be rejected" (Wang and Wang 2021 p55) (table 2.5). The solution is "rebalancing", where the operators move bikes from low to high demand areas. If the rebalancing is done during the night, it is referred to as the "static bike repositioning problem", but if during the day as the "dynamic bike repositioning problem" (Wang and Wang 2021).

Bike-sharing operators could offer incentives to users to return bikes to particular locations, to change their destinations, or to use the same bike for back and forth journeys (Wang and Wang 2021).

Wang and Wang (2021) proposed a "two-stage incentive model" which offered incentives to users at two points:

a) Pick-up of the bike - Usually a smartphone app will tell the user where the nearest bike is to their location, but a reduction in cost, say, could be offered if the user collects the bike from a certain location.

b) Drop-off of the bike - The advantage of FFBS is that the user can leave the bike at their destination point, but rewards could be offered for leaving the bike at a certain location.

These incentives seem to make a FBBS more like a SBBS. But what do users think of such incentives?

Wang and Wang (2021) surveyed 684 users in China in

[12] Also includes shared e-scooters (Wang et al 2022).

mid-2019. The questions were forced-choice (yes/no) about the acceptability of pick-up and drop-off incentives. Around 60% of respondents said "yes" to the former, and three-quarters to the latter. Wang and Wang (2021) explained further: "When asked to compare two types of incentive mechanisms, more respondents prefer drop-off incentives rather than pick-up incentives (46% vs 29%). The results support our idea that users have different attitudes towards two incentive mechanisms. In other words, users' perceived cost of pick-up incentive mechanism is higher. There are some possible reasons: (1) riding to an alternative destination is easier than walking to a new origin; (2) users may not trust the system and be afraid they cannot find a new bike; (3) it can be more certain if they have time to help when the trip is completed" (p59). This difference in preference was stronger for female users, and higher income users.

- Chang et al (2020) analysed 3.2 million journeys with FFBS cycles in Beijing in two weeks in May 2017. Three patterns of movement were observed during the day:
- Morning - from the city edge (residential areas) and nearby subway and bus stations (peak 7-9 am).
- Noon - within the city centre to restaurants and back to companies.
- Evening - from the city centre outwards (peak 5-7 pm).
- These patterns seem fairly obvious, but along with geographical data, bike providers can plan where the demand for bikes will occur and move them to those areas.

Table 2.5 - Patterns of shared bike use.

Bikeshare can also be used as part of integrated travel (the last or first mile) (eg: to travel from the station to the office) (known as "metro-bikeshare"). Liu et al (2022) analysed smart card data in Nanjing, China, in March 2016, which showed borrowing and returning time and location for SBBS (n = 24 661 trips by 7676 users).

The main users were 19-35 year-olds (around 60% of users), and they were non-regular/occasional users (ie: less than three days in the fifteen workdays studied). The researchers were able to show which metro lines were most popular for bike users, and that the routes cycled varied by age group. Adults travelled central city routes, but older adults cycled further. The findings

could help policymakers to improve the integration of metro and bikeshare use, particularly for non-regular commuters/travellers.

2.4.1. Cycling Generally

The "riding environment" is viewed as important to encourage cycling, but research with cyclists suggests "diverse perceptions of what constitutes a safe and comfortable riding environment" (Cabral and Kim 2022 p143).

The "Level of Traffic Stress (LTS) Framework" was designed to understand the suitability of infra-structure for cycling. There are four levels - the highest (4) is the most stressful situations and suitable for "Strong and Fearless Cyclists", and the lowest (1) or least stressful is for the "No Way No How" (non-)cyclists. While level 3 is "Enthused and Confident" and level 2 "Interested but Concerned" (Cabral and Kim 2022). Cabral and Kim (2019 quoted in Cabral and Kim 2022) found only three categories from their survey data in Edmonton, Canada - "Uncomfortable or Uninterested", "Cautious Majority", and "Very Comfortable Cyclists".

Cabral and Kim (2022) developed on this survey ("Bicycle Ridership and Traffic Stress Tolerance"). Sixteen video clips of various environments were included in the online survey (eg: shared use pavement (cyclists and pedestrians); protected bike lane on busy road; quiet' residential street), and respondents rated their comfortability to cycle in such situations.

For example, painted bike lanes on busy roads were favoured by "Very Comfortable Cyclists", while the "Cautious Majority" were happier with quiet, residential streets. There is some evidence that bike lanes on busy roads decrease the passing distance that motorised vehicles employ (Cabral and Kim 2022).

Parked cars was another issue, which "increases the risk of dooring and forces the cyclist to ride with traffic, or sandwiched between moving traffic and parked vehicles in the case of a bike lane" (Cabral and Kim 2022 p148).

The "Uncomfortable or Uninterested" were not comfortable with mixed traffic (ie: cars and bikes), even in residential areas with very low speed limit for cars, while overall "Very Comfortable Cyclists" accepted all situations more or less equally.

In terms of the differences in perceptions of cyclists, protected bike lanes were not seen universally

as comfortable. Thus, the importance of noting the different types of cyclists, particularly the infra-structure demands of reluctant cyclists.

2.5. SHARED MOBILITY GENERALLY

"Proponents of shared mobility options believe that they could lead to people owning fewer cars and reducing overall transportation costs. Some recent studies, however, show the opposite. For example, the usage of TNCs services may increase traffic congestion and vehicle miles travelled (VMT)" (Wang et al 2022 p301).

What about shared mobility services and greenhouse gases (GHGs) emissions? Bikesharing and shared e-scooters have been found to reduce such emissions compared to private vehicles, for instance (Wang et al 2022) [13].

In terms of carsharing, up to 50% average reduction across the lifetime of a vehicle for an individual, for example (Chen and Kockelman 2016). "Changes in travel patterns, reduced parking infra-structure requirements, and reduced fuel consumption were among the reasons for the savings" (Wang et al 2022).

A study in San Francisco between 2010 and 2016 (Erhardt et al 2019), however, found that ride-hailing led to higher VMT.

But the reduction in GHGs emissions depends on the method of measuring emissions, as well as factors like changes in travel behaviour, and state of vehicles (Wang et al 2022).

Wang et al (2022) analysed data from the 2017 US National Household Travel Survey (NHTS) focusing on 21-36 year-olds, and calculated GHGs emissions using the MOtor Vehicle Emission Simulators (MOVES) model and Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (GREET). These models were developed with US data to show on-road exhaust pipe emissions.

Establishing GHGs emissions comparison between individuals and their travel modes was difficult because of confounding variables like socio-demographic characteristics, travel preferences, and residential location. But GHGs emissions were higher on weekdays than weekends. Carsharing may encourage car-less families to

[13] E-scooter and bike-sharing are "what is referred to as shared micro-mobility. Micro-mobility targets to cover short distance trips as well as the first or last kilometre... Vehicles used for micro-mobility are light-weight, small and do not reach speeds of above 45 kph" (Krauss et al 2022 p206). Where studies have measured the distance, e-scooters are used for an average of 0.7 km (and no more further than 4 km), and bike-sharing for an average range of 1.3 to 3.1 km (Krauss et al 2022).

access them is one possible issue.

Privately-operated shared mobility services can exclude low-income individuals because of the cost. But what do low-income transport users want?

Wang et al (2021) analysed survey data from over 800 participants in low-income neighbourhoods in Detroit in 2018. The use of and attitudes towards fixed-route services, and ODRH were surveyed.

Three groups were distinguished from the responses:

i) "Shared-mode enthusiast" - Frequent fixed-route transit users and ride-hailing services. This group was younger, more educated, and had higher income, as well as high car ownership and smartphone use.

ii) "Shared-mode opponent" - Lowest use of all types of services. This group had the highest car ownership, and consisted "primarily of middle-age, middle-income, female vehicle owners who have high technology proficiency" (Wang et al 2021 p138).

iii) "Fixed-route transit loyalist" - Highest fixed-route use, but lowest ODRH use. This group included "middle-age/older black people from low-income households who lack access to personal vehicles and the Internet" (Wang et al 2021 p139).

Altogether, the use of and attitudes towards different modes of shared mobility depended largely on income, technology adoption, and car ownership, simplistically.

In a stated preference survey in Germany, Krauss et al (2022) investigated the different shared modes of travel (e-scooter, bike-sharing, car-sharing, and ride-pooling). These were compared to private cars, public transport, and walking in a survey completed by 1445 adults in all major cities in the country. Hypothetical travel choices were offered.

Cost was more important than travel time for car-sharing and ride-pooling, but equally important for all other modes of transport. Access was a key variable with shared services.

2.6. WALKING

Embracing SuT is linked to perceptions of safety,

and this is a gendered issue. For example, studies find that "women often experienced fear of sexual harassment or street crimes on public transport and when walking in a public space" (Hidayati et al 2020 p155) (appendix 2B).

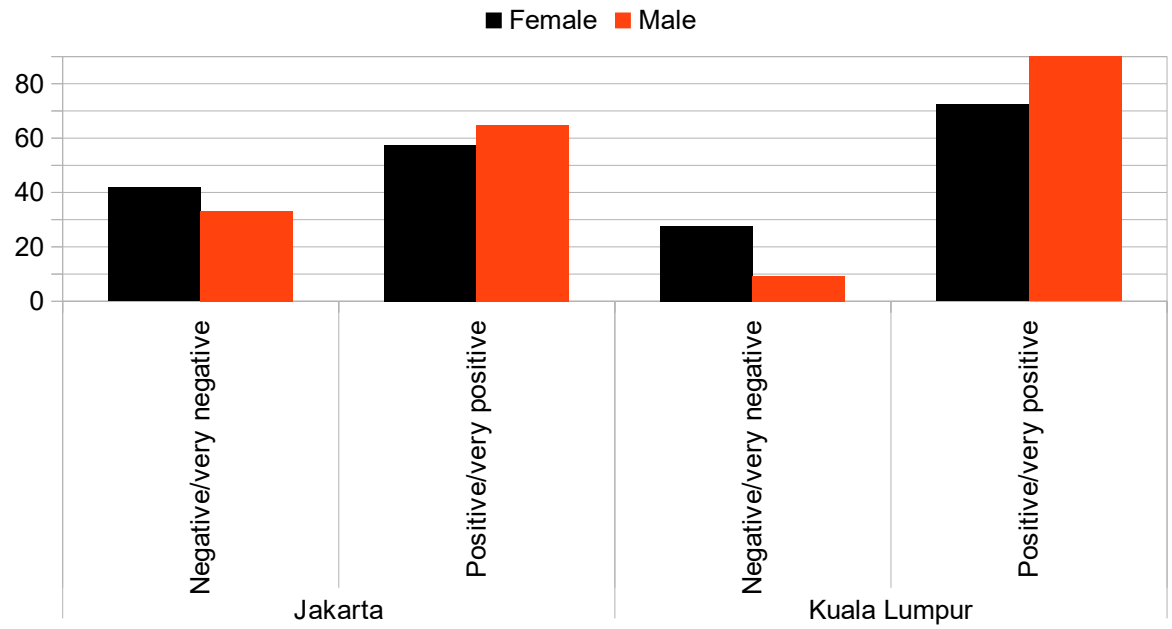
Hidayati et al (2020) outlined two sets of factors that influence the perception of safety:

i) External factors - eg: spatial configuration (eg: deserted streets or dead-ends); socio-cultural constructs (eg: norms about women's movement in public places).

ii) Internal factors - eg: age; physical ability.

Investigating these factors, Hidayati et al (2020) chose four neighbourhoods in Jakarta, Indonesia, and Kuala Lumpur, Malaysia, as case studies. Participants (n = 383) in these areas were surveyed about walking on these streets, while twenty-four video-recordings of pedestrians and vehicles were made.

The videos showed less female to male pedestrians in both cities, though there were more female pedestrians in Jakarta than Kuala Lumpur. Concerning the surveys, more female respondents reported negative perceptions of safety compared to males (figure 2.2).



(Data from table 3 p163 Hidayati et al 2020)

Figure 2.2 - Perceptions of safety (%) based on gender and city.

In Jakarta the negative perception of safety was linked to wariness about motorcycles (eg: "if (I) walk, (I feel) wary because (I am) afraid of getting hit by a motorcycle"; p164), while street crime was a concern in Kuala Lumpur (eg: "not so many people around, potential street crime"; p164). The difference in responses seemed to be linked to the difference in spatial configurations between the two cities. For example, in Jakarta street-facing buildings provided "strong natural surveillance on the street", while "[F]lats and apartments' entrances in Kuala Lumpur are often positioned away from the main street, discouraging potential social interaction on the street and lessening the natural surveillance potential" (Hidayati et al 2020 p165).

Hidayati et al (2020) continued: "Comparing Jakarta and Kuala Lumpur reflect differences in socio-cultural constructs, especially for walking. The video recordings of Jakarta show walking as part of social interactions beyond being a mere transport mode. In Kuala Lumpur, walking is a transport means to reach certain destination, and in the absence of attractors (eg: food hawkers) the area is likely to be devoid of other pedestrians" (p165).

2.6.1. Injury

Walking is a healthy "mode of transport", but roughly a quarter of a million pedestrian die globally each year in traffic crashes and millions are injured (Xu et al 2020).

Research has produced a wide variety of factors to explain pedestrian -motor vehicle crashes, including the characteristics of the pedestrians and the drivers, and environmental factors like the road geometry (Xu et al 2020).

Xu et al (2020) analysed official data for 2008-12 from the Hong Kong Transport Department, which included injury characteristics (eg: severity; type), and the crash environment (eg: speed limit; junction/road type; weather and light conditions). Seven variables were extracted from the dataset - number of vehicles, number of pedestrian-related casualties, speed limit, crossing facility, vehicle movement, gender, and injury location.

The most significant variables were traffic volume, and number of pedestrians, followed by location factors (eg: speed limit). Put simply, many vehicles travelling faster in the presence of many pedestrians increases the risk and severity of pedestrian injury.

2.6.2. Navigation

The strategies of navigation around an area include the use of proximal (near) cues (eg: nearby landmarks) or distal (far) cues (eg: stable, far away landmarks), and route (egocentric) information (eg: turn right when you reach the end of the street) or survey/orientation (world-based/allocentric) information (eg: using cardinal directions) (Barhorst-Cates et al 2021) (table 2.6).

- Salt Lake City, Utah, USA: "Start on 100 South facing the Salt Lake City Temple. Head east toward the Wasatch mountains [distal cue] to 1400 East. Turn south [allocentric information]. You have arrived at campus".
- Padua, Veneto, Italy: "Start by facing the Basilica di Sant'Antonio [proximal cue]. Turn left and walk to the first street on your right, then turn right [egocentric information] and continue to the Cappella S. Massimo. Turn left and continue across the bridge to campus".

(Source: Barhorst-Cates et al 2021 p1)

Table 2.6 - Two Examples of Instructions.

Barhorst-Cates et al (2021) compared the navigation preferences of two groups of fifty-six participants - from Salt Lake City in the USA and Padua, Italy. The two cities have different layouts, which it was hypothesised would influence spatial navigation. "The layout of Salt Lake City is a grid. The structure of the street names necessarily requires navigators to use an allocentric reference frame while navigating because they are organised in terms of cardinal directions (eg: 100 North, 200 South, 1400 East)... Padua, Italy, in contrast, does not afford a predictable and structured navigation experience, with the winding streets through tall buildings and lack of a systematic street name structure" (Barhorst-Cates et al 2021 p3).

The participants completed a number of laboratory-based cognitive tests related to navigation skills - the mental rotation test, and virtual-reality navigation tasks - and a selection of questionnaires about navigation behaviours, preferences, and anxieties.

There was no difference between the two groups of participants on the mental rotation test, which was expected by the researchers. In this test, participants were presented with two 3D shapes and must say if the shapes are the same. They are presented at different

angles and required mental rotation.

The virtual-reality tasks presented outdoor landscapes in which the participants had to navigate to a particular place. Later they were placed in different starting positions to find the same place. The Padua group used proximal cues to find the target place better, but the Utah group did not excel on distal cues. The former was predicted, but the latter findings may have been due to the "extreme difficulty" of using distal cues in the virtual-reality tasks (Barhorst-Cates et al 2021).

Overall, the study suggested that "more complex, irregular environments may facilitate better navigation abilities" (Barhorst-Cates et al 2021 p10).

2.7. URBAN RAIL TRANSIT NETWORKS

Urban rail transit networks (URTNs) include elevated and underground railway systems, usually in urban areas. Around the world, many of them are private companies, or public-private partnerships, with a desire to increase customer numbers. It is important, therefore, to understand the customer/passenger perspective.

Customer surveys have found common factors of importance, including "information on the train and in the stations, prices or value-for-money of the fares, quality of the ticketing service, responsiveness and helpfulness of the personnel, coverage of the network, attractiveness or aesthetic qualities of the stations, reliability, speed and frequency of the service, crowdedness of the platforms and trains, comfort and condition of the seats, facilities, safety and cleanliness on the train and in the stations and station accessibility" (Taecharungroj 2022 p194).

Taecharungroj (2022) used a different method, namely an analysis of comments about URTNs by travellers as posted on "TripAdvisor" in December 2020 (127 URTNs in 123 cities and over 185 000 reviewers). Machine learning was used to analyse the language in the reviews. From this analysis eleven dimensions within four themes were identified:

1. Activities (that travellers engaged in on the trains or at the stations):

a) Card - Special tickets or cards that make travel easier.
b) Ticketing - eg: queues or easy-to-use machines.
c) Direction - Understanding maps and finding the way

around.
d) Communication - Help from staff or locals if needed.

2. Settings (for the above activities):

a) Architecture - eg: space and retail.
b) Network - The integration of the URTN into the city.

3. Experiences (gained from the activities):

a) Performance - eg: worlds like "efficient", "fast", and "clean".
b) Safety
c) Crowd - eg: negative experiences of "rush hour".

4. Benefits (of such experiences):

a) Connectivity - eg: ease of use of URTNs in relation to travel to and from an airport.
b) Traffic - eg: URTNs as means to avoid vehicle traffic jams.

In terms of overall satisfaction, value-for-money was important, along with ease of use, cleanliness, safety, and efficiency.

This study was based on self-selected reviewers who were tourists, though they voiced similar concerns as commuters.

The building of a URTN offers travellers more choice. how do commuters respond to the extra option? Research tends to use "revealed preference" (RP) and "stated preference" (SP) surveys. The former collects data on actual travel behaviour, while the SP survey offers hypothetical choices, and it is more often used before new modes of transport are introduced (Gao et al 2022).

Gao et al (2022) focused on bus users with the introduction of a metro line in 2017 in Xiamen, China. Data from electronic travel cards were analysed. The decision to choose a bus or the metro depended on factors like travel time and distance, and length of metro line. For example, shorter travel time on the metro compared to the bus favoured its use.

2.8. HIGH-SPEED RAIL

The first high-speed rail (HSR) was opened in France

in 1981. It was presented as progress for all (socially inclusive), but the high price of tickets has lead some to argue that HSR is socially exclusive (Dobruszkes et al 2022).

Dobruszkes et al (2022) undertook a review of the evidence on HSR and social inclusion/exclusion. Firstly, the profile of passengers of HSR around the world:

- Gender - male.
- Age - 30s, 40s, and 50s.
- Income - higher than average.
- Social class/occupation groups - higher (strongest inequality here).

Church et al's (2000) study of London suggested seven potential factors explaining the unequal use:

i) Physical exclusion (eg: lack of facilities for disabled travellers).

ii) Geographical exclusion (eg: HSR not available in some areas).

iii) Exclusion from facilities (eg: poor access to other services).

iv) Economic exclusion (eg: high cost of tickets).

v) Time-based exclusion (eg: time not available for leisure travel).

vi) Fear-based exclusion (eg: fears about personal safety).

vii) Space exclusion (eg: first-class waiting rooms).

In surveys in Spain, the UK, and Italy, Pagliara et al (2017 quoted in Dobruszkes et al 2022), for example, found that economic exclusion was reported most commonly, along with geographical exclusion.

Dobruszkes et al (2022) commented: "In most HSR countries, travelling by HSR has made rail travel more expensive than travel by traditional, slower trains. HSR operators have set specific fare grids, usually away from public service obligations and from distance travelled. Through yield management, fares often fluctuate, depending on the day and time of travel and how far in advance the booking is made. Discount fares exist for

advance bookings, but not necessarily ad infinitum. As in planes or coaches, there could perhaps only be a limited share of seats, restricted to off-peak times and without flexibility" (p104). For example, tickets on traditional trains allow the use of any train on a selected day whereas HSR tickets specify a particular train with cost penalities for changing.

In China, Liu and Kesteloot 2015 quoted Dobruszkes et al 2022) found that city dwellers returning to their home village during holidays preferred slower, traditional trains for cheapness. "One interviewee stated that the extra cost of HSR equals three days of his/her salary. Simply said, the less these domestic migrants spend on travel, the more money they send back to their families in their home villages" (Dobruszkes et al 2022 p104).

The purpose of travel by HSR is another factor in who uses it. The dominant reason is often business. "Travelling for business purposes arguably filters the social groups aboard HSTs [high-speed trains] in favour of higher occupational groups, which also suggests higher incomes and higher education, on average" (Dobruszkes et al 2022 p105).

Dobruszkes et al (2022) concluded that HSR is "socially exclusive rather than inclusive" (p105). This fits with Pooley's (2016) observation that "although it is now possible to travel more quickly and easily than ever before, transport-related social exclusion is more likely than it was in the past" (quoted in Dobruszkes et al 2022).

Dobruszkes et al (2022) made a number of evaluative points, including:

a) Rail travel is "greener" than personal vehicle travel, but "greener" transport modes are "not per se socially inclusive" (Dobruszkes et al 2022 p105).

b) It is not clear if the profile of HSR passengers simply reflects the profile of long-distance travel passengers.

c) There is a question of "should costly and supposedly 'greener' HSR systems used by a social minority be (co)funded by public authorities, and thus by all taxpayers?" (Dobruszkes et al 2022 p106).

d) HSR systems may create economic impacts that benefit the non-users and this would "compensate" for the

inequality in use.

2.9. MULTI-MODE JOURNEYS

A journey may involve more than one mode of transport, and GPS tracking is poor at recording this information. The use of machine learning algorithms is one method, particularly using speed and acceleration to label the transport mode(s), and/or to layer information about bus and train networks on to the time and location data (Sadeghian et al 2022).

Sadeghian et al (2022) distinguished five modes of travel (walk, bike, car, bus and train) from the GPS data of twenty individuals in a city in Sweden in May-September 2017. GPS trackers recorded time, latitude, longitude, and speed every fifteen seconds. Extra information like bus routes, bus stops, and timetables was added.

The algorithms followed certain rules, like "walking" was a speed greater than 6 km/h but less than 12 km/h, and "cycling" was between 25-40 km/h, while a "stop" was two consecutive thirty-second periods of a speed of 2 km/h or less. Train mode was distinguished with information about the railway network and stations, and the use of a bus from timetables, bus stops, and specified bus lanes.

2.10. ELECTRIC VEHICLES

The switch to battery electric vehicles and plug-in electric vehicles (known collectively as plug-in electric vehicles; PEVs; Chakraborty et al 2022) from the internal combustion engine will reduce GHG emissions. But this is not inevitable.

There is the possibility of the "rebound effect", where driving miles increase with PEVs, and so "offset some or all the anticipated GHG emissions reductions" (Chakraborty et al 2022 p67). Generally, research has shown that when petrol prices drop, VMT increases, depending on vehicle type, vehicle age, household income, and household size (Chakraborty et al 2022).

Chakraborty et al (2022) investigated the potential rebound effect with PEVs with data from 4125 PEV owners in California collected in 2015-18 and in 2019. As well as odometer readings at two points in time, information was collected on characteristics of the PEV (eg: range of battery; cost of electricity to recharge), the household

and respondents, and the built environment (eg: urban; access to public charging points). Eight lifestyle preference variables were also included (likes store shopping; are pro-technology; have a stressful commute; dislike exercise; likes suburban living; likes outdoor living; need a car for family needs; utilises travel time).

The results were divided based on vehicles in the household:

a) Multi-vehicle - Residential electricity price had some influence on VMT in PEV, but this relationship was mediated by access to free workplace charging or discounted public charging.

The range of the PEV was important as was the cost of petrol/diesel for non-PEVs in the household. All lifestyle preference variables had an impact on VMT, but "likes suburban living" and "likes outdoor living" (eg: hiking and camping) were most important.

b) Single-vehicle - Electricity price had less of an influence on VMT. The researchers speculated that individuals with one PEV have less choice compared to multi-vehicle households. Similar relationships with lifestyle preference variables were found.

The researchers concluded that the factors influencing VMT by PEV were similar to those for internal combustion engine vehicles, and Chakraborty et al (2022) "do not identify the presence of 'rebound effect'" (p67).

The sample comprised of early adopters of PEVs, and data were not available on workplace or public charging availability and costs. The number of single-vehicle households was much smaller (n = 513) (Chakraborty et al 2022).

2.11. QUEUE-JUMPING

The opposite to sustainable transport is the growth of cars in certain countries like China, which leads to vehicle queueing, and unco-operative behaviours like "queue-jumping" (QJ) (or "forced lane changing" - ie: "the driver of the subject vehicle forcibly merges into the target lane on the condition that the lane-changing gap is insufficient"; Yang et al 2020 p97).

Yang et al (2020) explained: "Drivers jump queues at traffic bottlenecks or in rush hour with poor traffic conditions. From their perspective, queue-jumping can

improve their driving conditions by reducing travel delays and shortening travel times; however, for the whole traffic system, queue-jumping can disturb the order of traffic operation, slow down the traffic evacuation speed at bottlenecks, make congested nodes more complex and become the key factor hindering smooth traffic flow. In addition, when drivers jump queues, they face collision risks with other vehicles in the adjacent lanes and can even cause traffic accidents. In short, although queue-jumping can improve their driving conditions, this behaviour has negative impacts on the driving safety and efficiency of the whole traffic system" (p97).

Are there certain individuals who QJ, and what are the factors that affect it? Impatience is one possible answer, as seen in the "Type A" personality. Such individuals, it is known from previous studies, have more frequent braking, honking of the horn, speeding, and violation of traffic rules (Yang et al 2020).

Yang et al (2020) investigated QJ and Type A personality, attitudes, and risk perception with over two hundred questionnaire respondents in China (table 2.7). QJ items included "I think it's OK to jump the queue", "I hope the injured one is me if my queue-jumping leads to collision accidents", and "If I have something very urgent and important, I think it's OK to jump the queue".

- Driving Attitude Questionnaire (20 items) - eg: "Smooth driving is more important than always obeying traffic rules".
- Risk Perception Scale (6 items applied to QJ).
- Driver Skill Inventory (22 items covering driving skill, and safety motivation).
- Type A Behaviour Pattern (TAPB) Scale.

Table 2.7 - Main scales used by Yang et al (2020).

QJ was assessed in four situations:

a) Intersection entrances - eg: jumping back and forth between (less busy) left turn and straight-on lanes when queueing to go straight-on.

b) Road sections - jumping between lanes all queueing in the same direction.

c) Branch entrances - eg: making use of an empty

filter lane to overtake on the inside.

d) Highway exits - changing lane to off-ramp at last moment.

The frequency of QJ in each situation was self-reported from "never" (1) to "nearly all the time" (5). QJ in road sections was most frequent (only 11% of respondents said "never").

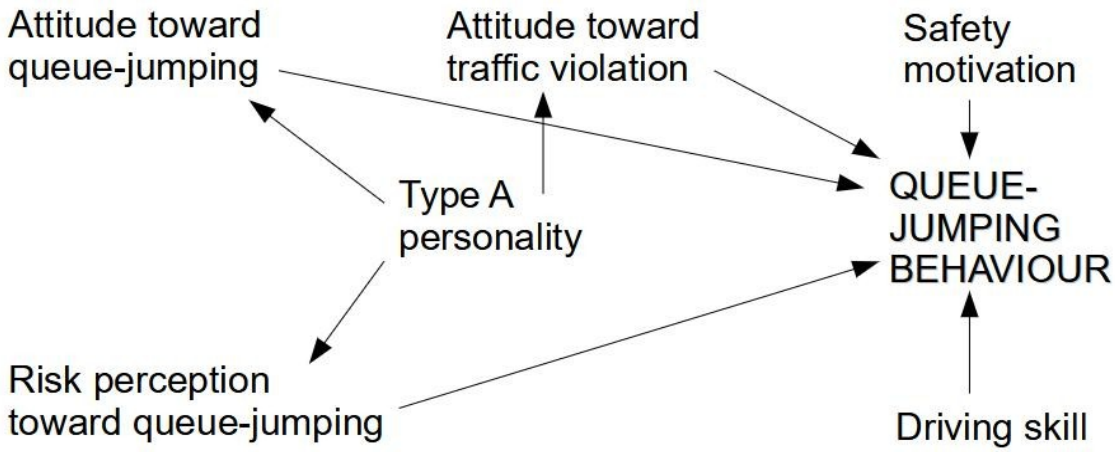
In terms of attitudes, not surprisingly, "drivers with more positive attitudes towards traffic violations and queue-jumping behaviours exhibited more frequent queue-jumping behaviours" (Yang et al 2020 p105). While "drivers with higher perceived risks for queue-jumping performed fewer queue-jumping behaviours" (Yang et al 2020 p105). Type A personality was significantly correlated with attitudes towards traffic violations, and QJ, but not with actual QJ behaviour. Another measure, "driving skill was positively correlated with drivers' queue-jumping behaviours..., meaning that drivers with higher driving skill performed more frequent queue-jumping behaviours. However, safety motivation was negatively correlated with queue-jumping behaviours...; specifically, drivers with stronger safety motivation performed fewer queue-jumping behaviours" (Yang et al 2020 pp105-106).

Putting all the scores together, QJ behaviour was greatest with low safety motivation, high positive attitude towards QJ, and low perceived risk of QJ. Type A personality impacted these attitudes, and so indirectly QJ (figure 2.3).

The findings were self-reported by the drivers, who were recruited at a shopping centre, vehicle maintenance centre, and an automobile parts shop. The majority were male (around 80%) (which did mirror the general driving population in China). Diagrams were used to help the participants in understanding QJ.

Yang et al (2020) admitted: "Although sensitive items were fuzzified during the questionnaire design and participants were told that this survey was anonymous during the survey, the effects of social desirability on the survey results could not be completely overcome" (p108).

They also accepted that "participants in this study were mainly non-professional drivers, and few participants were professional drivers. Thus, this study did not explore the differences in queue-jumping behaviours between professional and non-professional drivers. Professional drivers, as a special group, have



(Based on figure 1 p59 Yang et al 2020)

Figure 2.3 - Significant relationships between variables.

behavioural characteristics and cognitive psychology that are different from those of non-professional drivers due to their long working habits" (Yang et al 2020 p108).

2.12. PRIVATE CAR USE

2.12.1. Reducing It

Growing megacities like Beijing are facing the consequences of increasing personal car ownership and use, including congestion, and impacts on health. One strategy is to introduce driving restriction policies (eg: limiting car purchasing or fuel consumption; "road pricing"/tolls; high car parking costs).

In Beijing specific policies include car use restrictions, where specific cars were forbidden from entering certain areas based on license plate numbers for one day in a week, and the car license plate lottery programme, "under which individuals must win a lottery to get the permission of buying a private car" (Bao et al 2020 p49). Around thirty different "congestion mitigation" policies have been tried in the last decade or so (Bao et al 2020).

Bao et al (2020) surveyed drivers about traffic congestion, and solutions like "tradable driving credit" (TDC). Each month, say, drivers receive a certain amount

of credit to drive for free, and if they exceed their limit, payment is required, but unused credit can be sold.

The participants were 660 regular car commuters in Beijing. As well as questions about general travel behaviour and attitudes towards congestion, different TDC scenarios were presented.

Though the majority of respondents rated traffic congestion as a serious problem, the perceived benefits of personal cars outweighed such concerns (eg: status and prestige of ownership; pleasure of driving). "In sum, most respondents in Beijing think congestion and the environment issue caused by car use are very serious while much less of them believe the inconvenience caused by congestion in their personal car use is less serious" (Bao et al 2020 p54).

Around 60% of respondents believed that TDC could reduce congestion and personal car use. "As to the equity issue, nearly 65% of respondents think TDC is fair, and about 70% of respondents think it is fairer than the current vehicle restriction policy in Beijing. However, more than half of respondents think they will be worse off under the TDC scheme. In addition, nearly 60% of respondents perceive the TDC scheme as an infringement in their personal mobility" (Bao et al 2020 p54).

In terms of the scenarios, respondents were given a large credit allowance (ie: more than needed on average) or a small allowance (ie: less than needed). In the former case, 23% said they would increase their car use, 37% reduce it, and the remainder no change. With the small allowance scenario, the figures were 12%, 46%, and 42% respectively.

Willingness to change car use had the strongest link to symbolic meaning of personal cars (eg: prestige and status). High symbolic meaning was associated with increased car use in the TDC scenarios.

Certain socio-economic characteristics were also important in relation to car use change - income and family size. For example, larger household size and lower income were more likely to reduce car use when the TDC was reduced.

2.12.2. "Psychological Inertia"

Shifting from private cars to public transport is limited by "psychological inertia" (PsIn) (or in everyday language, "travel habits"). Gao et al (2020) explained that "psychological inertia or habit in the context of

travel behaviour is conceived as a non-deliberate and goal-directed tendency to repeat certain behaviours, mentally represented and automatic behavioural reactions" (p273). Past behaviour is central to PsIn.

PsIn has the following three properties: "learned from repeated behaviour, triggered by context-related or script-based process and leading to automatic behaviour without consciousness" (Gao et al 2020 p274).

Gao et al (2020) surveyed commuters in Shanghai, China, in autumn 2017. After questions about travel behaviour, participants were presented with scenarios involving different travel modes (private car, metro, bus, and taxi) and decision variables (cost, travel time, and crowding). The aim was to explore "travel mode shift" and PsIn.

PsIn was measured by eight items (eg: "I commute by car without thinking"; " I commute by car/metro without having to consciously remember") with five response options (strongly agree - strongly disagree).

There were over 1100 respondents, of which around half were car users.

Both car and metro users showed "more stickiness to their previously used mode" (Gao et al 2020 p285). PsIn meant that car users, in particular, made irrational decisions (eg: car use despite more expensive and longer journey time than public transport).

So, Gao et al (2020) concluded, travel mode shift to SuT required "policies that endeavour to break car users' psychological inertia by specifically interrupting the stability of daily travels" (p285). For example, license plate policies that restrict certain cars in the city on some days (ie: force car users to take public transport sometimes). Put simply, break the habit of getting into the car to commute.

Gao et al (2020) added that "we find the living environments have significant influences on the strength of psychological inertia such as 'inconvenience access to transit near home' and 'suburb-to-suburb commuting'. Therefore, increasing the convenient access to public transit can not only improve the service of public transit, but also potentially reduce car uses' psychological inertia for using car" (p285).

2.12.3. Increasing Car Use

In September 2017 a royal decree in the Kingdom of Saudi Arabia (KSA) reinstated the right of women to drive. "SHE Drives KSA" was a project to collect data in

2018 about women's motivations to drive. Al-Garawi and Kamargianni (2022) analysed the online survey data from over 10 000 women.

Around two-thirds intended to drive in the future against less than one-tenth who would not (and the remainder were unsure). Factor analysis of the responses to items about driving produced two key dimensions - "current mobility satisfaction" and "driving importance for women" (table 2.8).

Dimension	Items
Current mobility satisfaction	"I am happy with being driven". "The transport mode I choose makes me feel independent".
Driving importance for women	"Women driving is socially acceptable". "Women are capable of taking driving responsibilities".

Table 2.8 - Example of items to measure attitudes towards driving.

"Intention to drive" was linked to low scores on "current mobility satisfaction", and high scores on "driving importance for women". Other factors associated with "intention to drive" included receiving an education outside the KSA, being employed, and higher household income (but not with private chauffeurs).

The sample of this survey were more educated than the general population. Al-Garawi and Kamargianni (2022) explained: "It is assumed that this is related to the way our survey was disseminated to the public; through text messages to mobile phones. People who have received higher education, are usually more likely to have a smartphone that could be used to access the survey link, while it is also easier for them to navigate through the link" (p123).

2.12.4. Vehicle Ownership

Individuals have been categorised into groups based on their vehicle choice (eg: car, van, truck, sport utility vehicle (SUV)) and characteristics (eg: size, fuel type, make/model). For example, Mohammadian and Miller (2003) had twenty-four categories based on six vehicle sizes and four vintages (brand new, second-hand, used, old).

Analysing the 2017 National Household Travel Survey, and the Georgia Department of Transportation Emerging Technologies Survey (2017-18) in the USA, Wang et al (2022) developed a classification system based on vehicles in the household, and distinguished seven categories (or segments):

i) "Car-plus" (26% of the sample) - Main driver uses a car, but other household vehicles are available. This group mainly includes individuals aged 18-34 years old, higher educated and income, and urban dwellers.

ii) "Mostly car" (23%) - Car only option mostly. More females, single-person households, lower income, and non-White individuals.

iii) "SUV/van plus" (14%) - Main driver uses SUV/van, but other vehicles in the household. Largest share of 35-44 and 45-64 year-olds, mainly female and/or White.

iv) Mostly SUV/van" (10%) - Younger females with lower income who drive a SUV/van only, and includes single-person households. Interestingly, "individuals from this segment have very strong propensities toward owning vehicles... with negative attitudes towards non-car alternatives" (Wang et al 2022 p52).

v) "Truck-plus" (9%) - Main driver uses a truck, but other vehicles in the household. White male, less-educated, and rural dweller mostly. "They have the most negative attitude towards commuting... and modern urbanite lifestyle" (Wang et al 2022 p52).

vi) "Mostly truck" (8%) - No 18-34 year-olds, but mainly 65 years and above who drive only a truck. Single older males, less-educated, low income, and rural dwellers. The most negative attitude overall towards non-car alternatives.

vii) "Vehicle-abundant" (10%) - Drive a variety of vehicles owned by the household. Overwhelmingly male and/or White, middle-aged (45-64 years old), high income.

Looking at the categories in terms of gender, single females were more likely to be "mostly car" and single males "mostly truck". In the larger households, where the male was the main driver (ie: most miles travelled), "truck-plus" and "vehicle-abundant" were most common.

Where females were the main driver, "mostly SUV/van", "SUV/van-plus" and "car-plus" were more likely.

The researchers considered the findings in relation to reducing vehicles emissions. Firstly, younger females driving SUVs seems to be preference rather than household needs. "For example, a larger vehicle like an SUV may make these women feel safer and/or more in control while driving... For policy-makers interested in emissions reduction policies that encourage smaller, more environmentally friendly vehicles, incentives might be attractive to individuals from this segment, considering their relatively low household-serving needs and relatively low income. From an industrial perspective, this points to the market for so-called 'crossover vehicles', which are larger than cars but smaller and lighter (and therefore more fuel-efficient) than most current SUVs" (Wang et al 2022 p53). The personal preference for trucks among males is also an area for developing policy.

Attitudes towards owning a vehicle was another area to address. It appeared that lower income individuals had a strong pro-vehicle owning attitude. It was speculated that such individuals had unsatisfied vehicle ownership and that explained the attitude.

Interest in alternative (to petrol) fuel vehicles varied with vehicle preference (eg: truck drivers less interested in electric vehicles than SUV drivers).

Wang et al (2022) ended that individuals from the "mostly SUV/van" category may be incentivised to move to smaller, lower-emission vehicles (eg: by reducing relative cost of latter).

2.13. AUTONOMOUS VEHICLES

The hope for SuT is linked to developments in technology, like self-driving cars or autonomous vehicles (AVs). For some, the "passengerisation" (Mokhtarian 2018) of car drivers could lead to increased travel along the lines of this sort of logic: "Let's go to this special place 50 miles away – we can do our last hour of work in the car on the way there, and watch our favourite TV show on the way back (as we would have done at home)" (Kim et al 2020 p69) (appendix 2C).

Fully AVs are currently a long way off, and the question is how to predict behaviour changes. "One clever approach is to deduce some hints from the current services that can be considered as precedents of true AVs" (Kim et al 2020 p69). For example, cars with

chauffeurs. Harb et al (2018) provided thirteen individuals with a chauffeur for one week, and found that time in the car, number of trips and length all increased (table 2.9) (appendix 2D). But generally "such projections are... not perfect" (Kim et al 2020 p69).

- Individuals recruited via University Facebook in San Francisco Bay area: 5 retirees, 4 millennials, and 4 families.
- Data collected one week before chauffeur, one week (60 hours) of chauffeur, and one week after.
- Overall 83% increase in travel; 58% increase in number of car trips, and 30% reduction in walking with a chauffeur compared to without.
- Variation between three groups - eg: retirees increased travel by 341% compared to 4% among millennials.

Table 2.9 - Harb et al (2018).

In terms of modelling studies, Childress et al (2015), for instance, using data from Seattle, USA, calculated an increase in car travel of up to 20% due to "more/longer trips and some shifts away from other modes" (Kim et al 2020 p70).

What about asking people how they will behave with AVs? "Surveying public opinion regarding perceptions of AVs and their impacts is far from perfect because the future is highly uncertain, and what people think now may be only loosely connected to what they will actually do when the time comes" (Kim et al 2020 p69). Much of such research, however, has focused on perceptions of AVs generally rather than how people expected their travel behaviour to change (Kim et al 2020).

Kim et al (2020) analysed survey data from Georgia, USA, collected in 2017-2018 (n = 3244) about expectations of future travel in an all-AV era. Sixteen statements about potential behaviour change were presented (eg: "Go to grocery stores or shopping malls more often"; "Take part in more leisure activities after dark, because I wouldn't need to drive myself"; "Travel to more distinct locations for leisure"), with the response options of "very unlikely" (1) to "very likely" (5). The mean score for the items varied between 1.83 to 2.87 (ie: "unlikely to varying degrees"). Kim et al (2020) stated: "Whether these results are reflecting genuinely minor effects of AVs or an inability of respondents to envisage some

downstream consequences of AVs remains to be seen, but in any case they provide a useful benchmark of public perceptions" (p73).

Factor analysis of the data produced four factors/dimensions of behaviour change:

a) Distance - travelling further for everyday activities (eg: high scores on "Go to more distant restaurants").

b) Frequency - travelling more often (eg: "Travel to social/leisure activities more often").

c) Time flexibility - changing behaviour in other ways (eg: "Go to work/school at a different time to avoid traffic jams, since I can sleep/work in the car").

d) Long distance/leisure - longer and more often trips for leisure activities (eg: "Take vacations more often").

Further analysis of the data using the above factors produced six clusters of behaviour change:

i) No change (20% of respondents) - answered "very unlikely" to most statements. In terms of demographics, oldest and lowest-income respondents, and more likely to live in rural areas.

ii) Change unlikely (26%) - answered "unlikely" mostly. Slightly older than the average.

iii) More leisure/long distance (15%) - answered "likely" to statements about changing leisure activities, but "unlikely" to other statements. Male, middle-aged, White, and high-income individuals predominately.

iv) Longer trips (13%) - perceived travelling further generally in the future. More women than the other clusters.

v) More travel (14%) - expected to travel more in the future. This cluster had "the greatest share of non-white members and people with lower incomes and fewer household vehicles. However, they are favourable toward AVs, tech-savvy, and favourable toward urban life..." (Kim et al 2020 p74).

vi) Time flexibility and more leisure/long distance

(13%) - positive about future travel and benefits of AVs. The opposite to the "no change" cluster. "They are the youngest and most tech-savvy, like travelling the most, and are most favourable toward non-car options. This segment has the greatest share of workers and Atlanta residents. Finally, they have the most favourable perception of the benefits of AVs among all the clusters" (Kim et al 2020 p74).

Accepting that individuals may behave differently to how they predict when the time comes, this study showed the variety of expectations about AVs and future travel. Kim et al (2020) observed that "although many experts speculate that AVs will be a 'game changer' that significantly shifts behaviours, based on people's current opinions (which are admittedly likely to be conservative), the shifts may be more modest on average" (p76).

The researchers emphasised the potential difference between longer journeys and more journeys. They speculated that "it is relatively less burdensome to add more travel time to existing trips (especially if the time can be used pleasantly or productively) than to make entirely new trips..." (Kim et al 2020 p76). There are implications for the environment with more and/or longer trips, and the source of power of AVs will be crucial.

Zhu et al (2020) developed the media-based perceptions and adoption model (MPAM) of AVs, where "mass media and social media are deemed to affect the intention to adopt AVs through the mediators of consumer's belief and perception of AVs" (p83). Data were collected from 355 undergraduates in Beijing in 2019 to test this model.

Students were chosen as the sample because "young generations represent a critical group of early-adopters of AVs" (Zhu et al 2020 p86). About half the students were studying science and half liberal arts subjects. Given the choice, 17% preferred a fully AV, 73% semi-AV, and the reminder a manual car.

The survey included items covering aspects of the MPAM:

a) Mass media (3 items) - eg: "Through the mass media, I have a better understanding of AVs".

b) Social media (3 items) - eg: Someone in my social media circle of friends shared information about AVs".

c) Self-efficacy of AVs (4 items) - eg; "I believe I

can master the skills of using AVs".

d) Subjective norm (2 items) - eg: "People who influence my behaviour would think that I should use AVs".

e) Perceived usefulness (6 items) - eg: "Using AVs will enable more convenient travel".

f) Perceived risks (6 items) - eg: "Cyber-attacks or system failure may cause AVs to lose control" [14].

g) Intention to adopt AVs (3 items) - eg: "I predict I will try to use AVs in the future".

h) Intention to adopt public AVs (3 items) - eg: "I am willing to take an autonomous bus in the future".

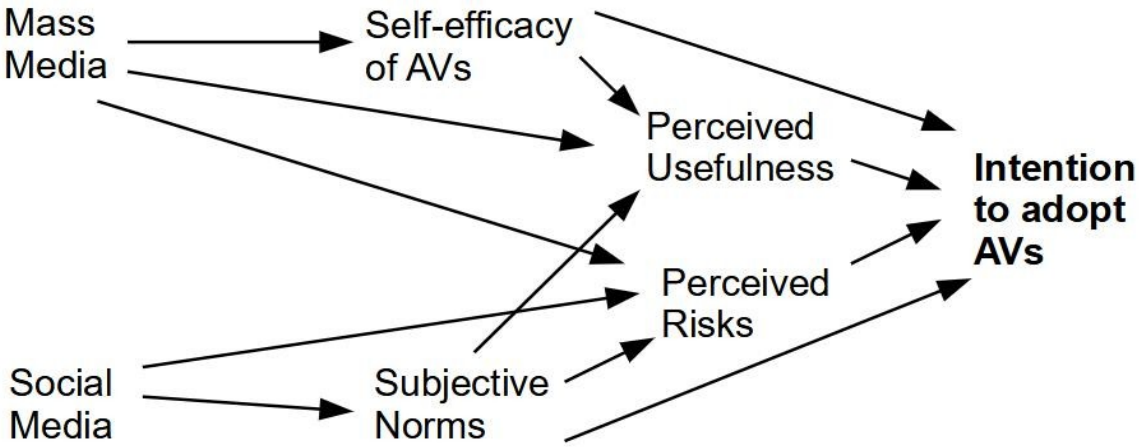
Media information was found to be a "foundational determinant" of perceptions of AVs, especially negative stories. More information was obtained from mass media than social media. "The more public information of AVs received by people, the more self-confidence of using AVs will be strengthened. Of course, mass media not only enhanced the perceived usefulness of AVs but also magnified the risks perception of AVs especially when more negative news is released by mass media" (Zhu et al 2020 p89) (figure 2.4).

Rahimi et al (2020) surveyed adults in the USA (in Florida and ten metropolitan areas) in spring 2017 about attitudes towards AVs and shared mobility options. Items covered general mobility and lifestyle preferences, perceptions of shared mobility options, attitudes towards private vehicle ownership, and perceptions of AVs.

When asked to rank different criteria, convenience/flexibility, reliability, and enjoy driving were most important for ownership of a private car, while less driving stress was important in relation to both shared mobility options and AVs. Data privacy, and higher travelling times are important negatives with shared mobility options, for instance.

Eleven latent (or underlying) factors were found that represented the different attitudes. These were grouped into four:

[14] An experiment by Yan et al (2022) using a laser tricked the cameras on AVs to interpret a red traffic light as green (Sparkes 2022).



(Based on figure 3 p88 Zhu et al 2020)

Figure 2.4 - Significant associations between variables of MPAM found by Zhu et al (2020).

i) General mobility-related attitudes:
A1 - Technology (eg: smartphone app use).
A2 - Choice Reasoning (eg: decision-making about transport mode).
A3 - Travel with Strangers.
A4 - Joy of Driving.

ii) Shared mobility-related attitudes:
A5 - Trust and Data Privacy Issue.
A6 - Multi-tasking.

iii) Vehicle ownership-related attitudes:
A7 - Utility of Private Vehicle.
A8 - Green Travel Pattern (eg: prefer transport mode other than private car).
A9 - Ownership Cost.

iv) AV-related attitudes:
A10 - Driving Assistance and Safety (eg: safer than cars with drivers).
A11 - Automation.

Distinct patterns based on demographics emerged. For example, "females expressed serious concerns about travelling with strangers (A3) and showed a higher tendency to use private vehicles due to privacy and

convenience (A7), they also showed negative attitudes toward the joy of driving (A4)" (Rahimi et al 2020 p152).

Wang, Wong et al (2020) investigated the acceptance of AVs in relation to identity as a car driver. So, "AV technology that depreciates the consumers' self-worth attached to the act of driving is likely to face considerable resistance from consumers. With the seemingly unstoppable penetration of AV technology, consumers may feel a pressing threat to their self-identities on the one hand and experience anxiety towards the technology on the other hand" (Wang, Wong et al 2020 p348).

Face-to-face interview data were collected from 353 drivers in Singapore. "Driving self-identity" was measured by three items - "Driving is part of how I express my personality", "Driving is a way of expressing my personal views", and "Driving is a way to express who I want to be". "Technology anxiety" was measured by four items (eg: "When given the opportunities to use AV technology, I fear I might damage it in some way"), and "willingness to try AV technology" by three items (eg: "I would like to try a friend's AV").

The resistance to trying AV was linked to "two irrational concerns" - high driving self-identity, and technology anxiety. In terms of demographics, male, and experienced drivers had high driving self-identity, and older, and lower-income participants higher technology anxiety. Wang, Wong et al (2020) suggested that "consumers may irrationally resist AV technology simply because 'this is not me'" (p357). This challenges theories AV technology acceptance that assume rational decision-making.

Reflecting on the limitations of their research, Wang, Wong et al (2020) commented that "this study is conducted in Singapore where the infrastructure of public transport is well established. The consumers' reliance on car transport is relatively low compared to countries such as America, Australia and New Zealand. Consumers in Singapore also show a high level of technology acceptance and trust in automotive public transport system" (p358). The sample did not include non-drivers, and few interviewees were over 55s (5% of total sample). This could be important because "AV technology may cater well to the elderly's mobility need, which makes the elderly group a special market segment of AV technology" (Wang, Wong et al 2020 p358).

Literature on pedestrian-AV interaction has

appeared. For example, the intention to cross in front of an AV, which is linked to the presence of a zebra crossing, a larger distance to the vehicle, the speed of its travel, trust, and younger age (Kaye et al 2022).

Kaye et al (2022), in an online survey in Australia (completed by 485 adults), found that "having confidence over one's ability to cross a road in front of an AV as well as the perception that important others would approve of this behaviour, were important in determining a pedestrians intention to cross a road in front of an AV" (p6).

In their research, Hossain and Fatmi (2022) included past life experiences as a factor in adoption of AVs, whether privately-owned or shared.

Previous research has looked at decisions about private vehicle acquisition and disposal, and how it is linked to life events, like birth of a child (eg: Oakil et al 2014), while other research has investigated changing commuting mode of transport. In this case, Fatmi and Habib (2016) found that "individuals' historical experiences such as moving from a rented to owned dwelling, moving closer to work location school, transit station and central business district, change in household income and vehicle ownership etc significantly affect their decision to either continue to use the same travel mode as well as switch to another mode" (Hossain and Fatmi 2022 p58).

Hossain and Fatmi (2022) analysed data from the "Travel Technology and Mobility Survey" (TTMS) in British Columbia, Canada in 2019. The TTMS includes housing history, vehicle ownership record, employment history, life events, and information about household members, along with household income, and technology ownership. There were two key questions about AVs as privately-owned (AVO) or shared (SAV), which were scored on a five-point scale. Over 11 000 responses were available.

For AVO, overall, 24% were "somewhat interested", and 17% "very interested" (scores of 4 and 5 out of 5) compared to 40% ("somewhat uninterested" and "not at all interested"; scores 1 and 2). For SAV, 44% scored 4 or 5 (interested) vs 36% (uninterested; scored 1 and 2).

The key variables in AVO were lifetime exposure to technology, history of suburban dwelling, high-income, and full-time work, for instance. While reported interest in SAV was explained by lifetime exposure to technology, historically living close to school/work, lower income, and full-time work, for example.

Exposure to technology predicted interest in AVs

generally. Attitudes also played a role. "For instance, pro-environment individuals are likely to own and share AVs. Pro-shared-mobility individuals are more likely to share AVs whereas they are less interested in owning" (Hossain and Fatmi 2022 p57).

2.13.1. Automated Buses

AVs are usually assumed to be private cars, but there are also automated (or autonomous) buses (ABs). These are "an emergent technology for public transport being able to move more than ten passengers simultaneously on programmed routes without a driver" (Zoellick et al 2021 p55).

Zoellick et al (2021) explored the attitudes towards ABs, and particularly the trust in them, in four focus groups with twenty-one adults in Germany in 2018. A number of themes emerged from analysis of the transcripts. These can be presented as means through which individuals can develop trust for a new technology.

i) Comparison to other technologies - ABs did not exist, so the participants had to imagine the technology. This was done by comparing them with known mobility technologies. For example, "S4m" said: "... I mean you fly on the plane and you don't even know if there is a pilot sitting at all in the cockpit or if automatic piloting is set and he is sleeping or, I don't know, drinking coffee, or being on the toilet and nobody's there. Anyhow, you don't know it. There is a closed door. So you're sitting in a plane and you don't know if someone has the control..." (p59).

ii) Curiosity or scepticism - Eg: "C1f" said: "I think that, when the railway was introduced everyone made a big fuss out of it; they just didn't understand it. When the first cars came there were people that resisted and said I would never get into one and in the end they got driven to their own funeral and well, they didn't make that experience, but yeah... Moreover, there are always... especially with these kinds of cars (a/n: self-driving) I have the feeling that there will always be difficulties. People just can't accept it straight away" (p60).

Whether individuals approached (curiosity) or avoided (scepticism) ABs depended on pre-existing knowledge and situational factors (eg: the speed of the ABs).

iii) Perceptions - Control was an important concern, as expressed by "C1f": "Well, if the car drives and we see a cat, is there a possibility to press stop somewhere, as a passenger..." (p60).

iv) "The black box" - As the algorithm and technology were opaque, participants anthropomorphised the ABs decision-making (eg: "what he thinks").

Zoellick et al (2021) concluded that "potential users can build trust towards a previously unknown concept through different trajectories" (p63).

2.14.1. Shared Autonomous Vehicles

Shared AVs (SAVs) combine the best of both worlds. In an internet survey in the USA, Bansal et al (2016), for example, found that technology-savvy males in urban areas reported being more likely to use them, and older adults less likely.

Maeng and Cho (2022) studied the consumer preferences around SAVs in South Korea. Initially 602 online respondents, and then 1000 face-to-face interviewees (aged 20-69 years) were offered six choice sets, which varied the waiting time, cost, and factors like liability for an accident. Three types of SAVs were included - fully AV, partial AV, and with driving assistant.

The liability for an accident emerged as important as cost of the service. Maeng and Cho (2022) explained: "The results show that people with a higher income prefer to use SAV service if service providers are responsible for an accident. Contrarily, older people, drivers, and people with a low income prefer to use SAV service if the accident's liability lies with the automobile manufacturer. We also find that SAV service usage increases when the level of autonomous driving technology is high or liability for an accident lies with the SAV service provider or automobile manufacturer" (p9).

2.14. PEAK-AVOIDANCE POLICIES

Peak-time public transport demand is high, while at other times there is more room. Is it possible to distribute the demand more evenly? For example, in December 2015 a pricing strategy was introduced on the Beijing subway which discounted tickets for travel before

7 am from certain stations, while "Free before 7" was tried in New Zealand (Wang et al 2020).

"Peak-avoidance policies" vary in success because commuters' responses are "complex", and depend on many variables. including flexibility of work hours, attitudes towards commuting, and socio-demographic variables (Wang et al 2020). A weakness of the policies is an "one size fits all" approach. Wang et al (2020) argued for heterogeneity, and collected data from the Beijing subway to support this view. Anonymous smart cards were given to 5946 commuters before and after the introduction of the discounts for travel before 7 am in December 2015.

Analysis of the travel data distinguished four groups of commuters:

1. Short-distance, low variation travellers - fixed departure time and destination with a maximum commute of one hour.

2. Long distance, low variation travellers - as (1) but their commute was longer than one hour.

3. Multi-transfer, low variation travellers - as (1), but much of the commuting time spent changing trains than travellers (eg: waiting; moving between platforms).

4. Flexible, high variation travellers - great variety in departure time (and destination).

Categories (3) and (4) were found to be insensitive to reduced prices, but categories (1) and (2) could be encouraged to travel earlier (say, 20 minutes before usual departure time). The latter two groups appeared to be "common office workers".

Category (3) commuters had "a short commute (lowest fares), but with a long duration of travel, indicating multiple transfers during the subway commute congested travel routes that lead to time spent getting through crowds... As their journey is the most complicated and uncertain, their departure time is the most fixed, and they are the most sensitive to the required change in departure time among the four types of travellers... It is difficult for such travellers to change their behaviour..." (Wang et al 2020 p102).

Category (4) travellers were the smallest group with highest flexibility, and probably relatively high incomes. "This would help explain why they are the most insensitive to little monetary savings and are more sensitive to time" (Wang et al 2020 p102).

In summary, different policies by the subway authorities "are likely to be more effective than the current 'one size fits all' approach" (Wang et al 2020 p92).

This study did not have demographic information about the commuters as it was anonymised.

2.15. DISCOURAGING FLYING

2.15.1. Academics

Nevins et al (2022) considered air travel by university academics attending conferences and meetings. Such behaviour is responsible for a large amount of an institution's carbon footprint.

Arsenault et al (2019), for example, surveyed academics at their institution (Universite de Montreal), and found that the work-related travel footprints of the academics exceeded a typical person in Germany.

Nevins et al (2022) placed "doing academia" flying in the context of universities' desire to "decolonise the curriculum". "Setting aside for now the fact that what decolonisation means or should mean is the subject of much discussion, what is striking about these growing calls for decolonisation is they typically say nothing about matters of environmental consumption" (Nevins et al 2022 p232) [15].

Hoyer and Naess (2001) were particularly critical. They challenged "the notion that 'knowledge industries' lead to the 'dematerialisation' of society, to a reduction in environmental resource consumption and pollution. 'Knowledge workers', the authors point out, typically undertake a lot of professional travel, 'often made with the most energy consuming and environmentally harmful modes of transport'..., this despite their being 'green' in that they 'care' about environmental matters. Such conference-going, Høyer and Naess [2001] suggest, makes the individual part of what they call the global elite. It also contributes, they contend, to socio-economic inequality 'between an ever more mobile cultural elite and other, more marginalised groups'" (Nevins et al 2022 p235).

Parncutt (2019) suggested an ageist, racist, and sexist aspect. Using a "1000 tonne rule" (ie: the burning of one thousand tons of carbon-based fuels), this "leads to the death of one future human being; with such deaths

[15] "In a broad sense, the decolonisation of academia concerns 'addressing how the forces of racism and colonialism have shaped our past and present' (Muldoon 2019...)" (Nevins et al 2022 p233).

having disproportionate impacts on the elderly, the negatively racialised, and women. To help make sense of such inequities, Nevins (2014), in exploring professional academic travel, develops the concept of dysecologism. This refers to the appropriation of an unsustainable and socially unjust share of the biosphere's resources in a manner that concentrates benefits in the bodies and places associated with a privileged minority, and detriments in those associated with a disadvantaged majority—producing life-limiting outcomes in a manner similar to, say, imperialism and racism" (Nevins et al 2022 p235).

Sonne et al (2019) gave the example of six academics flying from Copenhagen to Oslo for a meeting on polar bear habitat and melting Arctic sea ice would each be responsible for one square metre of Arctic summer sea-ice melt (Nevins et al 2022).

Work-related flying, however, is not always by choice. Academics fly for a variety of reasons including "job-related structural pressures and individual motivations; identity-enhancement and the 'cultural capital' gained via aviation-related mobility; a refusal to inconvenience oneself by taking slower, more time-consuming modes of transport; moral licensing (eg: 'I compost and recycle and therefore have earned the right to travel by air'); conscious self-indulgent practices and escapism; a consumer-society-produced sense of being trapped in particular practices and thus feeling that other options are not viable; and the notion that flying is a basic right... Fear of damaging one's career is also a powerful factor in limiting the willingness of many academics, including those worried about climate change, to fly less" (Nevins et al 2022 p235).

Accepting their position as "three White male academics at elite institutions in countries with long histories of empire-building", Nevins et al (2022) ended: "Flying — not in and of itself, but as a practice that embodies profligate consumption by a small slice of the world's population and the associated harms that result — is anti-thetical to such solidarity. In this regard, the project of decolonisation, as an endeavour to transform a world that allows for high and unsustainable levels of consumption by a global minority..., provides valuable impetus to flying less efforts within the academy" (p237).

2.16. COMMUTING AND LEISURE TRAVEL

"Flexible work arrangements" (FWAs) (eg: working from home) can reduce commuting, and consequently energy consumption, traffic congestion and CO2 emissions, unless there is an increase in non-work trips (a rebound effect) (Viana Cerqueira and Motte-Baumvol 2022).

Viana Cerqueira and Motte-Baumvol (2022) investigated this data from the UK National Travel Survey (NTS) for 2002 to 2017, which involves a seven-day travel diary. The data on over 25 000 heterosexual couples with dual income were especially chosen by the researchers for analysis.

Non-work travel was divided into three categories for each partner - escorting children, shopping, and leisure/personal.

FWAs for the female partner was associated with increased CO2 emissions for the couple on non-work travel (ie: increased trips). Most of this increase was due to the woman escorting the children. It had been previously observed in the Netherlands that women working part-time make more escorting and shopping trips (Schwanen et al 2007).

There was a lesser increase in emissions when the male partner had FWAs. For couples without children, the increase in non-work trips was reduced because of the lack of escorting of children.

In terms of general allocation of activities, Viana Cerqueira and Motte-Baumvol (2022) explained that the "main findings demonstrate that although the partner who benefits from FWAs tends to carry out domestic provision and maintenance activities, the allocation of tasks within the household is still asymmetrical. Thus, flexible work arrangements result in a greater allocation of domestic and maintenance activities to women than their male counterparts. Conversely, men with alternative work patterns tend to convert their free-time into leisure and personal trips, while still allocating a significant share of domestic-related trips to their partners" (p246). These gender inequalities increased with the presence of children.

Altogether, reduced work-related travel of FWAs was compensated by increased non-work travel. The data from the NTS, however, were limited about working hours, and non-work trip purposes, for instance.

Magdolen et al (2022) investigated the "compensation hypothesis" (Naess 2006) in relation to urbanites. This hypothesis proposed that "people living in densely built

areas compensate for deficiencies of the residential environment with a higher leisure travel demand" (Magdolen et al 2022 p291). German data were used to test the hypothesis: "People in major German cities behave sustainably in their everyday mobility and compensate for this with a high level of climate-impacting long-distance travel" (Magdolen et al 2022 p292).

Two surveys were analysed - Berlin (2016 and 2017) and Munich (January-February 2020) (n = 893 respondents). Travel activities were collected with the "travel skeleton", which is a form of travel diary, capturing the usual weekly travel, including typical leisure activities in everyday life as well as vacations and touristic travel.

Analysis of the responses produced four groups or classes:

i) "Long distance actives" (39% of the sample) - Many short-term long-distance travels per month. Use public transport to commute, but car for leisure travel.

ii) "Annual holiday-makers" (27%) - One long-distance trip per year.

iii) "Travel-addicted urbanites" (13%) - Frequent leisure travel of all distances, and longest distance for vacations. Most use of public transport daily, but high flying use for leisure.

iv) "Regional (infrequent) travellers" (21%) - Few vacations and trips.

"Travel-addicted urbanites" (and "long-distance actives" to some extent) provided evidence for the "compensation hypothesis".

Commuting time and distance are influenced by the separation between job and residential locations. "Jobs-housing balance" is where individuals live closer to their job location and so reduce commuting distance (Zhou et al 2022).

Commuting distance is influenced by education level, for example, as in higher educated individuals travel further, job type (eg: manufacturing industry employees work closer to home), and house prices (Zhou et al 2022).

Underlying this is the simple fact of where an individual can get a job. "If more jobs are provided for workers, then more workers will choose local jobs and commuting distances will be decreased. However, more jobs

will attract more workers from other areas commuting to the area" (Zhou et al 2022 p272).

2.17. MISCELLANEOUS

The views of children on urban travel tends not to be studied, or the caregivers' perceptions of their children's travel is collected. There are a few studies of children, often older, using a variety of methods (Humberto et al 2022).

Humberto et al (2022) described the use of the "philosophy with children" approach with 217 5-6 year-olds and their caregivers in eleven sessions in Sao Paulo, Brazil. This approach involves a series of play-based activities to encourage the children to talk about their mobility and transport use (eg: listening to a story called "The Bus Ride"; answering the question, "Where do we play?"). The transcripts of the sessions were analysed.

Around two-thirds of the children had an active means of travel to school (walk or bicycle) and the rest used motorised vehicles. The distance to school, household income, and being female influenced whether a motorised vehicle was used.

The themes from the sessions included the way to school, travel generally, family and joy (eg: "When I went to my grandmother's house, I rode my bike and asked my grandfather to take the training wheel off"), play, and fear (eg: "We must watch the street so the cars don't run over us, we have to check if the light is red, otherwise the cars run over us") (Humberto et al 2022 p173).

"The perceptions of both fear and pleasure seem to be best perceived by children using collective modes of transport (eg: school buses and public transport), which seems to reveal the potential of such transport modes, even if motorised, to promote experiences of joy and conviviality that are not perceived by children using other motorized modes such as the private car..." (Humberto et al 2022 p175).

The "philosophy with children" approach was able to hear from "an age group that is commonly disregarded in most of transport-related studies involving children and youth" (Humberto et al 2022 p176).

2.18. APPENDIX 2A - PUBLIC TRANSPORT LOYALTY

Fu (2022) investigated passenger loyalty in Suzhou, China, with a paper-and-pencil based survey in 2012 of 429 passengers at the main bus station. Questions were asked about six factors - perceived service quality, corporate image, perceived value, satisfaction, complaints, and loyalty.

According to previous research, "whether customers stay with the current service provider or switch to other competitors is determined by the quality of service that customers have received or perceived. That is, a service provider's success in the long term largely depends on its ability to maintain a large and loyal customer base by providing high-quality service that meets or exceeds customers' expectation" (Fu 2022 p28).

Overall, Fu (2022) found that passenger loyalty was significantly influenced by perceived service quality, customer satisfaction, corporate image, and complaints.

The respondents were subsequently divided into three groups:

- Group 1 - "Satisfied" (25.2% of sample) - Highly satisfied with the service, and few complaints. More likely to be male, aged 30-60 years. Perceived quality, value, and image were the most important factors.

- Group 2 - "Dissatisfied" (17.5%) - Opposite to Group 1. More likely students and younger adults. This group had limited income, and perhaps, "are 'captive' users who wish they could use alternative modes. Hence, they have recognised that the PT [public transit] service is a good value for money, but they simply do not want to use it for some reason that is not captured in the current study (eg: a desire to be perceived as successful)" (Fu 2022 p36). The same three factors as Group 1 were important.

- Group 3 - "Neutral" (57.3%) - Moderate satisfaction and complaints. More likely females, aged 30-60 years. Loyalty in this group was linked to perceived quality, corporate image, and satisfaction.

This study showed that perceived service quality and value were most important to all passengers, but secondary factors varied between the groups.

The sample was opportunity, and did not include non-

users of public transport. The study was not able to distinguish loyalty among passengers who had a choice and not (ie: captive or non-captive users) as no questions were asked about private car ownership. Another limitation was the measures of the different factors used.

2.19. APPENDIX 2B - FEAR OF VIOLENCE DURING NOCTURNAL TRAVEL

Fear of violence influences all modes of transport used by women at night. Zhang et al (2022) investigated "fear of violence during nocturnal travel" (FVNT) with Chinese data from 2015. Mixed sex focus groups were created, and a survey was designed with questions like, "Do you feel fearful when waiting alone at an outlying bus station during nocturnal travel?", and "Do you feel fearful when walking alone in a backstreet during nocturnal travel?".

The survey was completed by over 11 000 respondents in two cities. FVNT was reported by over 60% of women (compared to 20% of men), and in particular, waiting alone at a bus stop, and walking alone in an underpass or backstreet at night. It was observed that "fear-induced self-protection measures cause women's voluntary retreat from certain dangerous public places and transport means" (Zhang et al 2022 p180).

2.20. APPENDIX 2C - TRAVEL-BASED MULTI-TASKING

"Travel-based multi-tasking" (TBMT) describes activities other than navigation performed while travelling, varying between talking, looking out the window, to working on a laptop.

Russell et al (2011), for example, observed travellers on buses and trains in Wellington, New Zealand. Two-thirds of individuals were categorised (out of twelve pre-set categories) as "looking ahead/out of the window" at some point. Other common categories were "listening on headphones", "talking", "texting", and "sleeping/eyes closed". This is an example of a structured observational study, which "suffers from inter-observer variability. There is also a range of information that is not possible to be collected through observation, for instance, socio-demographics, attitudinal profile, and trip purpose. Questionnaire-based survey overcomes the shortcomings of structured

observation through collecting self-reported information" (Sun and Wang 2022 p85).

TBMT activities have been classified by type, including active/passive, or work-oriented/pleasure-oriented (Sun and Wang 2022).

Keseru and Macharis (2018) distinguished seventy-five variables related to TBMT, including age, gender, travel mode, trip duration, time of the day, and travelling alone or not. These variables can be summarised in three groups (Sun and Wang 2022):

i) Travel mode - Simply, "travellers riding on public transport services are found with wider range of in-vehicle activities, compared to driving or taking private car services" (Sun and Wang 2022 p86).

ii) Trip-related characteristics - For example, morning commute (outward journey) (eg: preparing for the day) vs afternoon commute (return journey) (eg: "switching off"). More time is spent on working in the former case (Sun and Wang 2022).

iii) Socio-demographics - eg: differences in "productive" and "non-productive" activities due to age or gender.

Sun and Wang (2022) surveyed travellers in Singapore in January 2021. Firstly, 136 individuals completed an open-ended questionnaire about TBMT activities, and from the responses, a list of twenty-six activities were created. Each activity was rated "no proportion" (1) to "all" (5) based on amount of time spent on it. Three types of trips were distinguished - home to work, work back to home, and leisure. A total of 886 online respondents were recruited.

Use of the Internet (eg: "Facebook"), and messaging/emailing were most common in all types of trips.

Concentrating of the use of information and communication technology (ICT), and social activities, these were influenced by travel time, trip cost, age, and gender, for example. Longer trip times were associated with less time in these activities. "Trip cost is positively affecting people's willingness to engage in ICT/productive activity during commute. Those who are paying more for trip costs (eg: riding on taxi) are more likely to perform productive tasks since they may be more keen to utilise their travel time compared to others" (Sun and Wang 2022 p92). Younger respondents, and males

spent more time using ICT.

Overall, five groups of TMBT activities were identified - passive (eg: looking at scenery), ICT/productive (eg: work-oriented use), ICT/leisure, traditional (eg: listening to music), and social (eg: talking).

2.21. APPENDIX 2D - HARB ET AL (2022)

How will travel behaviour change in the future with personally owned AVs? Harb et al (2022) collected data to answer this question with an experiment involving forty-three households in California who were provided with personal chauffeurs (in lieu of privately owned AVs) for two weeks. Smartphone tracking apps were used to collect travel diaries, and to compare the behaviour with two weeks of no-chauffeur.

The presence of the chauffeur did not influence the decision to stay at home or travel out, nor the time of day of travel. But there was evidence of "zero occupancy vehicle" (ZOV) trips in the form of sending of the chauffeur on errands. This highlighted a difference between the experiment and AVs, but one participant gave this feedback: "I currently work in downtown where it is expensive to park, so once it [the AV] drops me off I would send to go to park somewhere on the outskirts of town where it can find free parking for the day, and then it would pick me up and take me home" (p287). Such ZOV trips need to be considered in understanding future travel behaviour.

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3. PRO-ENVIRONMENTAL BEHAVIOURS

3.1. PAYING ATTENTION

"Private-sphere environmentally significant behaviours" (Stern 2000) are those that individuals perform in their everyday lives (eg: mode of transport used; waste management), and are distinct from "environmental activism", which is designed to 'influence the behaviour of the policy system, and of the broader population' (Stern et al 1999...) or non-activist behaviours in the public sphere, which support environmental activism" (Meis-Harris et al 2021 p1).

In order to perform such behaviours, individuals must pay attention to certain cues, and this is what Meis-Harris et al (2021) investigated. They stated: "If peoples' goals bias their attention towards the stimuli that are relevant for their goal pursuit, within the context of environmental sustainability, those who have strong goals to sustain the natural environment would show attentional biases towards environmentally relevant objects" (Meis-Harris et al 2021 p2). The researchers called this "pro-environmental tendencies" (ProETs), and included five types - explicit environmental beliefs, environmental identity, goals to reduce carbon emissions, self-reported environmental behaviours, and the desire to

behave in environmentally friendly ways (Meis-Harris et al 2021).

Meis-Harris et al (2021) performed two studies.

Study 1

Aim: To examine the relationship between ProETs and environmental attentional biases.

Participants: Ninety-eight psychology undergraduates in Australia.

Procedure: Attention was measured by the dot-probe task. Participants were asked to respond as a soon as a dot appeared somewhere on a computer screen. Immediately before the dot, an environmentally relevant and an irrelevant picture were shown. "If attention is directed toward the environmentally relevant stimulus, participants would respond to a dot appearing in the location of that stimulus faster than to a dot appearing in the location of the environmentally irrelevant stimulus" (Meis-Harris et al 2021 p4). The speed of presentation was 300 ms and 1250 ms.

The participants subsequently completed questionnaires measuring their ProETs, like the Low Carbon Readiness Index (O'Brien et al 2018) (eg: "I work hard to reduce my greenhouse gas omissions whenever possible"), and the environmental behaviour in the last four weeks (eg: "I leave the TV on while I'm doing other things in the house").

Findings: Attentional bias was found for environmental harmful objects (eg: paper cups), but not environmentally beneficial objects (eg: reusable bottles).

Study 2

Aim: A replication of Study 1 in Australia and Germany, and with a different presentation time (500 ms).

Participants: One hundred and eight undergraduates in Germany and 120 in Australia.

Procedure: As Study 1, except presentation time.

Findings: As Study 1.

Overall, the findings were viewed as supporting the hypothesis that individuals with ProETs pay attention to environmentally relevant stimuli, but specifically to threatening stimuli. "Those who with stronger goals to protect the natural environment may be more likely to attend to environmentally harmful objects, be potentially more aware of the threats that they pose to the natural environment, and therefore may attempt to avoid them if they can" (Meis-Harris et al 2021 p8).

But the strength of the findings was weak, and so may have been affected by methodological. The researchers, thus, recommended replication with alternative measures of attentional bias, and of ProETs. For example, Beattie and McGuire (2012) had used an implicit association test to measure implicit attitudes towards low carbon footprint and attention to climate change-relevant images, positive nature images or neutral household objects.

3.1..1 Ocean Imagery

Engel et al (2021) started with this point: "Understanding how society thinks about and behaves toward the ocean is a priority for moving forward with a marine sustainability agenda" (p1). These researchers focused on mental images (perceptions) of the ocean and the relationship to this agenda. Using a word-association technique, individuals in Newfoundland, Canada, described their mental images of the ocean.

The data were collected between November 2018 and March 2019 via self-administered questionnaires, and 773 coastal residents from forty communities participated. Firstly, participants were asked to list three words that came to mind when picturing the ocean (word-association technique). Then there were attitude items like, "I am concerned about how the ocean will look like in the future". Next they were asked about the acceptability of four marine activities - commercial fishing, recreational fishing, oil and gas extraction, and transportation. Finally, pro-environmental behaviours were measured with items like, "How often do use plastic bags in grocery stores?".

The words chosen were categorised into eighteen groups, and then into six major dimensions (in order of importance):

1. Psychological impression - eg: "beautiful", "big", "frightening".

2. Place identity - eg: "home", "heritage", "Newfoundland".

3. Utilitarian - words associated with fisheries and livelihood (eg: "income", "living").

4. Environmentalist - words describing concerns for the ocean and the human impact (eg: "garbage", "respect").

5. Naturalist - words related to marine biodiversity (eg: "wildlife", "corals").

6. Governance - words related to marine management/mismanagement (eg: "greed", "unprotected").

In terms of the demographics, "psychological impression was higher among women and older generations, whereas naturalist was higher among young people. Environmental related images were higher in urban areas" (Engel et al 2021 p1).

The acceptability of using the ocean in different ways correlated positively with utilitarian images, but negatively with other groups. Pro-environmental behaviours were reported more by individuals who used images not categorised as utilitarian.

The researchers commented on their method: "Top of mind associations offer an opportunity to assess the types of images that come to mind when people think about the ocean. Investigating ocean cognitive imagery enhanced the understanding of people/ ocean relationship. In future, however, affective imagery should be included in the analysis. Affective imagery explores the degree in which people feel that their associated images are positive or negative and are often measured using a five-point scale ranging from extremely negative to extremely positive... Because respondents were asked to use words to represent their images, the associated words may not represent the whole image as there might be aspects that people have trouble setting single words on. Instead of limiting imageries to single words, future research would benefit if asking respondents for the first three thoughts, words, images or phrases which come to mind when thinking about the ocean" (Engel et al 2021 p6).

3.2. PARENTAL INFLUENCE

Children's pro-environmental behaviours develop within the context of socialisation, and specifically parent-child interactions. For example, in a study in Denmark, Gronhoj and Thogersen (2009) found similarities in attitudes between parents and children on buying environmentally friendly products, saving electricity, and waste management. Gronhoj and Thogersen (2012), developing on this study, found similarities in attitudes between parents and adolescents. A third study (Gronhoj and Thogersen 2017) found "a high correlation between parents' and children's motivational qualities. In other words, parents who were internally motivated to act pro-environmentally often had children whose behaviours were also internally motivated" (Jia and Yu 2021 p2). These studies, however, only concentrated on three types of pro-environmental behaviour (Jia and Yu 2021). Other studies have not found the same results (Jia and Yu 2021). Furthermore, the studies are mostly in rich countries, and "pro-environmental behaviour should be culturally and contextually dependent, which means that environmental actions may differ from one culture to another... For example, in many developed countries, taking public transportation for a short distance would be considered a pro-environmental action; however, in many developing societies, such action would be considered a matter of daily life" (Jia and Yu 2021 p2).

Jia and Yu (2021) wanted to understand the mechanism of parental influence and used the idea of "action, communication, and engagement" (ACE). "Action" refers to children observing the pro-environmental behaviour of the parent(s), "communication" is the parent(s) telling children about the subject, and "engagement" is involving children in the pro-environmental behaviours.

The researchers recruited 518 6-14 year-olds and their parent(s) in five major Chinese cities to complete questionnaires. Twenty-three questions covered pro-environmental behaviour (eg: "I turn off lights when not needed, eg: leaving the room"; "I keep the water running when I wash the dishes"; "I reuse blank paper") for both parents and children. The children completed separate questionnaires covering "action" (eg: "How often does your father recycle?") and "communication" (eg: In your everyday life, how often does your parent talk about the benefits of acting environmentally friendly?"). Technically, this was perceived action and perceived communication. Parents were asked about "engagement" in terms of involving their children in fifteen daily pro-

environmental behaviours.

There was a significant positive correlation between parents' and children's pro-environmental behaviours. This relationship was mediated most strongly by perceived action. Put simply, children needed to observe their parent(s) doing the pro-environment behaviour in order to copy it. This fits with the Social Learning Theory (or observational learning). "Asking children to act pro-environmentally or discuss environmental issues may not be as robust as acting pro-environmentally in front of children and participating in the pro-environmental activities with children" (Jia and Yu 2021 p6).

The researchers covered four main types of pro-environmental behaviour - reuse and recycling, waste disposal and management, behaviour outside the home, and energy conservation. The findings were weakest for the latter. This may be because energy conservation includes adjusting the heating, which is usually the role of the parent(s).

In terms of the five cities, Beijing had the strongest relationship. Beijing has a severe pollution problem, and this may make parents more environmentally conscious.

Finally, older children were more aware of the parent(s)' pro-environmental behaviours.

3.3. CHANGING IDLING BEHAVIOUR

Car exhaust emissions produce air pollution, and idling engines are a part of this that can be changed. Abrams et al (2021) explored the use of persuasive messages to encourage drivers to turn off their engines while stationary at railway crossings (for 2-3 minutes).

The messages focused on three aspects of attitude change - outcome efficacy (the belief that changing the behaviour will produce the desired outcome), self-regulation (directing attention towards the self), and social norms.

For four weeks in the summer of 2018 (Tuesday to Thursday, three one-hour periods) the researchers performed a field experiment using different signs at two railway crossings in Canterbury in southern England. The outcome measure was the number of drivers who turned off their engine while queueing at the railway crossing (ie: waiting for a train to pass and the barriers to open). Week 1 involved no sign, and was used as the baseline.

In each of the next three weeks a different sign was placed close to the railway crossing - (i) "Join other

responsible drivers in Canterbury. Turn off your engine when the barriers are down " (social norm message), (ii) "Turn off your engine when the barriers are down. You will improve air quality in the area" (outcome efficacy message), and (iii) "Think about your actions. When the barriers are down pleasure turn off your engine" (self-regulation message).

Compared to the baseline (27% of drivers turned off their engine), the social norm and outcome efficiency messages produced a significant increase in turning off engines (39% and 34% of drivers respectively), but not the self-regulation message (30% of drivers). The impact was stronger when more vehicles were queueing, but the social norm message was most effective with nay number of vehicles.

Air pollution measures showed that turning off the car engine did reduce concentrations at ground level. Over 6500 vehicles were included in the field experiment.

Table 3.1 shows the findings of social norm messages in two previous studies by this research group. Note that the previous studies presented the messages via signs held up by research assistants compared to signs attached to regular street poles in Abrams et al (2021).

Reflecting on the findings, Abrams et al (2021) were surprised that the self-regulation message had no impact on behaviour because Mahmood et al (2019) had found a significant effect. Abrams et al (2021) speculated that the message may have been perceived as moralising, and this can lead to "defensive, reactance or disengagement" (p8).

STUDY	MESSAGE	TURNING OFF ENGINE (%)
Mahmood et al (2019)	"Show others you care"	38% (not significant increase from baseline - 29%)
Player et al (2018)	"When barriers are down 25% of motorists turn off their engines"	41% (significant increase from baseline - 28%)

Table 3.1 - The previous studies using social norm messages by the same research group.

The messages were presented for a relatively short time, so the long-term impact was not studied. Abrams et al admitted that it is "possible that efficacy might decrease with repeated exposure because drivers habituate to the presence of the road sign and pay less attention to it. A more dynamic form of signage (eg: electric signs

that vary a series of different messages) could be particularly effective, especially if sensors could adapt messages based on current traffic volume" (p8).

3.4. PRO-SOCIAL BEHAVIOUR

There seems to be a relationship between neighbourhood green space and the development of pro-social behaviour in children. Putra et al (2021b) explained that three pathways may be involved in this relationship:

i) Harm mitigation - Green space reduces air pollution, for instance, which can have a negative impact on children's development, and buffer against psychological stressors.

ii) Building capacities - Facilitate social interactions as children play, and consequently pro-social behaviour.

iii) Restoring capacities - Here "the restorative effect of green space helps develop pro-social tendencies through increasing positive emotionality via attention recovery" (Putra et al 2021b p2).

But how the green space is accessed is important, and "caregiver perception of neighbourhood green space quality might have direct influence on children's contacts with and spending time in green space" (Putra et al 2021b p2).

The Longitudinal Study of Australian Children (LSAC), begun in 2004 (Wave 1), and up to Wave 6 in 2014, provided data on nearly 5000 pre-school children. Putra et al (2021a) found a positive association between caregiver's perception of the quality of neighbourhood green space and their child(ren)'s pro-social behaviour in that data. Putra et al (2021b) extended the analysis.

At each wave of LSAC pro-social behaviour of the children was caregiver-reported (eg: "Share readily with other children"), and the caregivers also scored the green space quality (eg: "There are good parks, playgrounds and play spaces in this neighbourhood").

The perception of green space quality was divided into six groups:

I - "consistently in low quality" (across all

measurement points) (4% of the sample).

II - "consistently in between low and good quality" (23%).

III - "consistently in good quality" (28%).

IV - "increasing quality from good to very good" (as child got older) (11%).

V - "decreasing quality from very good to good" (20%).

VI - "consistently in very good quality" (13%).

The rating of pro-social behaviour over a ten-year period was higher in group VI than group I, and in group III compared to group I.

Putra et al (2021b) noted: "The limitation of this study was caregiver-reported green space quality. The changes in caregiver reports of the quality of neighbourhood green space over time might not reflect the actual changes or changes to physical features of green space since their perceptions could be contingent upon several factors. For example, gendered playing patterns may play important roles for caregivers in deciding what characteristics of green spaces are suitable for boys and girls" (p9).

3.5. COSTS

3.5.1. Personal Cost

Bokman et al (2021) pointed out that "[I]f human behaviour is to become more sustainable, however, people will have to be willing to sacrifice personal gains and benefits for the sake of sustainability. In many everyday situations, consumers will have to make decisions that involve making trade-offs between what is good for the self and what is good for the environment" (p1).

These researchers investigated this trade-off with a dilemma of flying (swift by bad for the environment) versus travel by another means (slower but better for the environment). The participants were 212 individuals at a Swedish university, who read the following statement:

"Let us assume that you will fly from Stockholm to Umea. This trip lasts 1 hour and will emit 99 kg of CO2.

{The Swedish Environmental Protection Agency recommends that each of us should not use more than two tons of greenhouse gases per person and year, which amounts to a maximum of 38 kg of CO2 per week on average.}

If you had the opportunity to reduce the CO2 emission to 22 kg, would

you be willing to travel for a longer time than 2 hours [6 hours] instead of 1 hour?" (p3).

The length of the alternative travel time was varied between two and six hours (known as the anchor), and the control participants did not see the Swedish Environmental Protection Agency paragraph (known as the normative message) (table 3.2).

	Low Anchor: 2 hours	High Anchor: 6 hours
Normative Message	1	3
No Message	2	4

Table 3.2 - Four independent conditions of the experiment.

The willingness to travel for longer to help the environment was significant in the High Anchor/Normative Message condition (ie: condition 3 above). Individuals who scored high on a measure of environmental concern showed a stronger effect.

The findings suggested that external factors in the form of the normative message influenced the trade-off decision between self and environmental interests. Put another way, when the personal cost is "expensive" (ie: long alternative travel time), knowing that others are willing (or recommended) to do it (normative message), encourages individuals to make the sacrifice.

3.5.2. Social Cost of Carbon

For policy-makers to make a cost-benefit analysis of a policy in relation to climate change, there needs to be a way of pricing CO2 emissions. One measure is the "social cost of carbon" (SCC), described as "an evaluation of the future costs of emitting one extra tonne of CO2 into the atmosphere, taking into account all the effects of climate change" (Jessoe and Moore 2021 p262). More formally defined as "the dollar value of climate change damages imposed globally by an additional (that is, 'marginal') ton of carbon dioxide (CO2) emissions (or its equivalent)" (Rode et al 2021 p308). Calculation, however, is easier said than done.

Rode et al (2021) attempted to calculate the portion of SCC attributable to energy expenditure. Higher temperatures will reduce the demand for energy for

heating, but there may be an increase in energy demanded to power cooling. The researchers used data from 146 countries. It was estimated that "the relationship between energy expenditure and temperature depends strongly on per capita income: energy use will increase substantially on very hot or very cold days in the wealthiest places, but not in most low-income locations" (Jessoe and Moore 2021 p263).

Previous research had calculated that increased demand for air conditioning occurs with household income of US$ 10 000 and above per year (eg: Davis et al 2021).

Rode et al (2021), however, estimated that energy demand for heating will decline globally and so offset any increase for cooling.

Jessoe and Moore (2021) noted that Rode et al's (2021) estimates "do not account for potential future decreases in the price of cooling (or heating) technologies. If the price of air conditioning falls over time, and if poorer countries expand their electricity grids, then air conditioning might be adopted sooner than projected. For example, price decreases were key to the adoption of air conditioning in the United States in the mid-twentieth century" (p263).

3.6. IMAGINING ALTERNATIVES

The ability to imagine cognitive alternatives to the status quo is a basis to actual change. "Environmental cognitive alternatives might include a human population that attempts to integrate with nature rather than trying to dominate it. In the context of climate change, cognitive alternatives to the environmental status quo would likely include technological changes, such as imagining a world without fossil fuels, powered by solar and wind energy" (Wright et al 2020 pp2-3).

Wright et al (2020) developed the Environmental Cognitive Alternatives Scale (ECAS) to measure this phenomenon. Firstly, the researchers created thirty-six relevant statements (items), which were presented to 406 US participants recruited online, along with measures of of beliefs about climate change, and environmental behaviour. Ten items were found to distinguish between respondents most clearly and they became the ECAS (table 3.3) (figure 3.1). A replication with 404 more online participants was performed to confirm the item selection.

High scorers on the ECAS are able to imagine cognitive alternatives. This significantly positively correlates with belief that climate change is occurring,

for example, and has negative consequences.

- It is easy to imagine a world where we no longer use fossil fuels.
- I can think of numerous methods of achieving a world where carbon emissions are reduced below current levels.
- I can easily imagine a world where people see themselves as integrated with nature, rather than masters over the natural world.
- When I imagine what an ecologically sustainable existence for humans would be like, I can picture it in detail.

(Source: Wright et al 2020 table 1)

Table 3.3 - Example of items from ECAS.

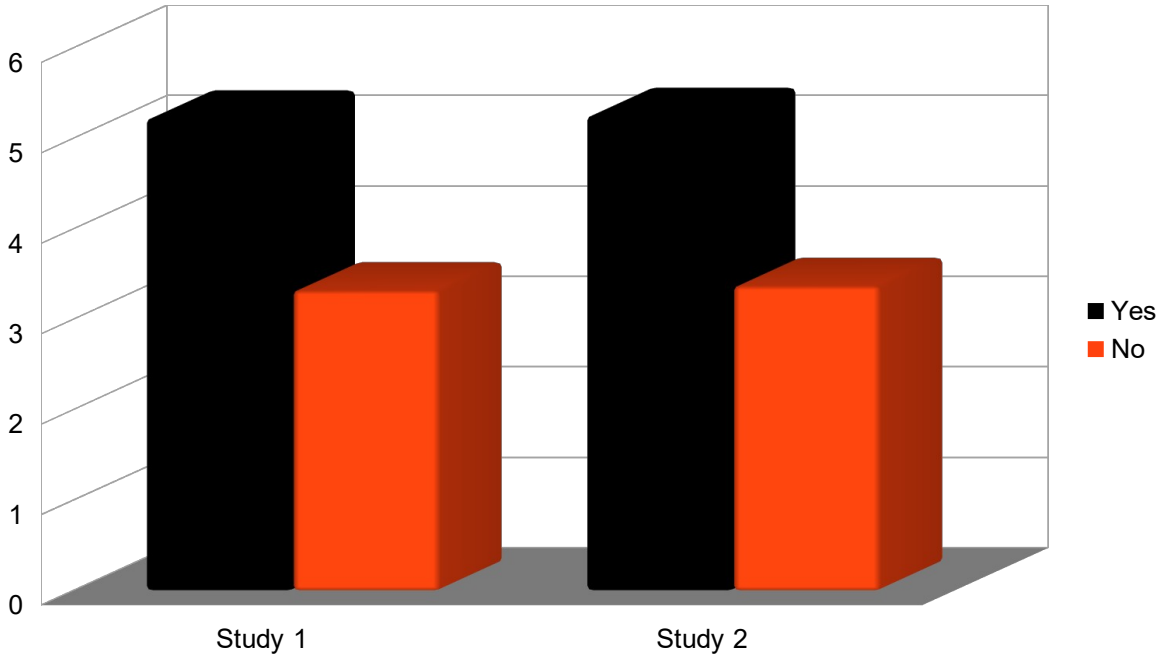

Figure 3.1 - Mean score (out of 7) on ECAS based on response to the question: "Can you imagine a world, different from the current state of our own, in which humans have a harmonious and sustainable relationship with the rest of the natural environment?".

3.7. SOCIAL IDENTITY

"Reminding people of their membership in social

groups, most notably groups that are perceived to be effective in fighting environmental crisis, can help to overcome feelings of helplessness and to motivate (collective) action in favour of environmental group goals" (Barth et al 2021 p2). This is the idea of social identity as a means to motivate collective action [16].

"Identification is a necessary pre-condition for group-based action to occur. Individuals need to clearly categorise their self in a group, and they need to feel psychologically invested in the group" (Barth et al 2021 p2). For example, a strong motorist identity is associated with less willingness to adopt sustainable modes of transport (Murtagh et al 2012).

Schulte et al (2020) reported meta-analyses of nine studies by their research group that showed that identification with a pro-environmental opinion-based group positively correlated with the intention to participate in pro-environmental collective action. This identification was a stronger predictor of action than individual pro-environmental values.

The different studies used different measures. For example, identification with a group advocating for local cycling issues, or those committed to reducing CO2. The intention to act was measured rather than the actual collective action.

3.7.1. Ingroup Conformity

In the USA, for example, "concern about climate change and environmental issues more generally is becoming increasingly politically polarised..., and this divergence filters down into pro-environmental behaviours and purchases at the individual level" (Geiger et al 2020 p1).

Geiger et al (2020) investigated political conformity and pro-environmental behaviours (appendix 3A) in four studies, two with US undergraduates, and two with US users of MTurk. The first study (Study 1), with 84 students, was a survey of political orientation, and own and others' recycling behaviour.

Self-reported recycling behaviour was associated with perceived recycling by other students of the same political orientation (ie: liberal or conservative).

[16] Fritsche et al (2018) have adapted the social identity theory (Tajfel and Turner 1979) into the "Social Identity Model of Pro-Environmental Action" (SIMPEA). "The model describes how people appraise, and respond to, large-scale environmental crises in terms of collective cognition and action" (Barth et al 2021 p3).

"Results showed evidence for ingroup conformity effects: the more political liberals believed other political liberals recycled, the more they self-reported recycling. Conversely, political conservatives' self-reports of recycling were predicted by perceptions that other political conservatives recycled more" (Geiger et al 2020 p4).

In the second study (Study 2) with 54 more students, participants were informed during the experiment that their recycling behaviour was similar to the average conservative/liberal (own political orientation) (conformity condition) or opposite political orientation (non-conformity condition). This false feedback was given in between two rounds of a task to sort photographs of recyclable and non-recyclable items. Participants in the non-conformity condition changed the number of items to recycle between the first and second rounds. The conformity condition did not change.

Study 3 was a replication of this experiment with 407 online participants. It confirmed the findings about the non-conformity condition, but also participants changed their behaviour in the conformity condition.

The final study (Study 4) with 619 online participants added a control group who received no false feedback. This study did not replicate the previous findings. The researchers suggested that the study taking place during covid-19 had an impact: "For example, changes in lifestyles and media coverage occurring as a result of the pandemic could have dampened automatic associations between political ideology and recycling behaviour..." (Geiger et al 2020 p9).

Overall, the studies showed political conformity to perceived ingroup norms in relation to recycling behaviour. Political conservatives showed less recycling because of the perceived norm that political conservatives do not recycle, and the liberals the opposite. But Study 4 suggested that more research was needed to understand political ingroup conformity and pro-environmental behaviours (Geiger et al 2020).

3.7.2. Referent Group

The referent group is the group that the individual pays attention to in terms of social norms. The group can be specific (eg: "neighbours") or generic (eg: "citizens of the country").

Mertens and Schultz (2021) studied the impact of different types of referent groups in a study of

household recycling. A field experiment with over 1500 households in a city (Solana Beach) in California was performed in 2019. Households were randomly assigned to one of six conditions that varied the referent group and information provided:

1. Highly specific social normative feedback condition - Information about the household's level of recycling compared to the five closest neighbours, and clear information about what types of material to be placed in the household recycling bin for collection.

2. Exemplary social normative feedback condition - Recycling information, and how the household compared to the best recyclers in the city.

3. Generic social normative feedback condition - The household compared to similar households in the city, along with recycling information.

4. Statewide target social normative feedback condition - The household's rate of recycling compared to the target for California, and recycling information.

5. Information only control condition - No referent group.

6. No-contact control condition - No information about recycling nor referent group comparison.

Note that the households were randomly told they were better or worse than the referent groups.

The outcome measure was the volume of recycling in the appropriate bin, measured before the study (baseline) and 1-4 months later. Technically, a diversion rate was calculated (ie: the amount of appropriate recyclable material that was diverted from the general rubbish to recycling bin).

Households in the referent conditions (numbers 1-4 above) diverted significantly more than the control conditions (numbers 5 and 6 above). Households who were told that their average was below the referent group were more influenced. Overall, the highly specific (number 1 above) and generic (number 3 above) conditions had the strongest impact.

The researchers gave the households information once at the beginning of the study, and the impact "did not persist past month 2 of follow-up, which was consistent with literature suggesting that feedback is more likely

to produce longer-term changes in behaviour when it is repeated" (Mertens and Schultz 2021 p8).

In summary, positive behaviour change occurs with feedback about a referent group that is specific to the individual. Generic referent groups were better in changing behaviour than no comparison to social norms, however.

3.7.3. Co-Operation

The "dilemma of the commons" is a theoretical example in understanding co-operative behaviour. The idea is that there is a common area of land and individuals are free to graze their animals upon it. But excessive use will lead to degradation of the land, and everybody will suffer. So, co-operation involves each individual controlling their animals' use. There is a real-life situation in the Monduli district in north Tanzania with Maasai pastoralists.

Rabinovich et al (2020) investigated identification with the group/community as a way of sharing resources (ie: to encourage co-operation). The researchers surveyed 297 individuals in eight local communities in the area. Community identification was measured by two items: "I have strong relationships with other people in my community", and "I am happy about being a member of my own community" (each scored 1-5).

"In line with the social identity theorising..., the results supported the core prediction that social identification with a group of actors is linked to willingness to protect resources shared by that group" (Rabinovich et al 2020 p8). But stated willingness to co-operate was measured rather than actual behaviour.

3.7.4. Group Competition

Group competition can be fostered to improve sustainability, as Nockur and Pfattheicher (2020) showed with a fishing game. In this computer-based game, participants could catch as many fish as they wanted in a "season", and gained a small monetary reward for fish caught ($0.10 per 20 fish). At the end of the season, the number of fish was doubled for the next season. Each participant played against three "players" (algorithms programmed to overfish). The game ran for six seasons, which was not disclosed to the participants, and the most sustainable participants received a monetary bonus in the

experimental condition. The dependent variable/outcome measure was sustainable behaviour, measured as the percentage of fish take from the total (ie: 0% to 100%). It was decided that 12.5% was a "fair share" that would provide individual reward but allow sustainability into the future.

Study 1 involved 842 participants recruited online. Overall, the mean number of fish taken was 24.17%, which is significantly higher than the "fair share". In the competition (experimental) condition (ie: to be the most sustainable fisher), the mean was 20.32%, which was significantly less than the control group (28.16%). "Although group competition increased sustainable behaviour, extraction rates in the group competition condition were still above the sustainable rate with which the resource could regenerate to its original size" (Nockur and Pfattheicher 2020 p4).

The algorithm players overfishing was varied in Study 2 (with 1104 more online participants). This study had two independent variables - competition or not, and the behaviour of the algorithm players (sustainable or unsustainable) (table 3.4).

	Competition condition	Control condition
Algorithm overfishing	1	3
Algorithm sustainable fishing	2	4

Table 3.4 - The four conditions in Study 2.

Overall, the mean was 24.05% of fish taken, and the competition conditions were significantly less than the control conditions (21.70% vs 26.73%). The behaviour of the algorithm players had no impact overall. But it did on competitive individuals (as measured by items like, "I enjoy competing against others"). Individuals high in dispositional competitiveness overfished themselves when the algorithm players overfished.

The following methodological points can be considered:

i) The participants were recruited via Amazon MTurk. It allowed a large and varied number of participants, but was limited to individuals who used that website and chose to participate.

ii) The study was online, which, Nockur and Pfattheicher (2020) admitted, "limits control over what participants are doing. However, we employed several methods to screen for careless responding" (p8). The game ran for only six "seasons".

iii) The applicability of the fishing computer simulation game to real-life situations (ecological validity).

iv) Other variables and measures (eg: personality measures; incentives for sustainability).

In summary, group competition to be more sustainable did improve sustain behaviour to some extent (at least in this online game).

3.7.5. Being Moved

Landmann and Rohmann (2020) explored how "being positively moved can enhance collective action" (p2). The researchers surveyed 203 individuals actively involved in protesting against the clearing of areas of the Hambach Forest in Germany by a coal mining company, and those sympathetic to the protest. The questionnaire covered issues like:

a) Collective efficacy appraisal (eg: "Together, people can reduce coal mining significantly").

b) Emotions - anger, sadness, joy, fear, and being moved. Participants ticked a list of adjectives.

c) Identity (eg: "Acting environmentally friendly is an important part of who I am").

Firstly, the emotional responses. "The mining company elicited higher levels of anger, sadness, and fear, whereas the protection campaign elicited higher levels of being moved and joy... Hence, thinking about the Hambach Forest does not elicit a single definitive emotional reaction. Instead, emotional reactions depended on which aspect of the situation (ie: the mining company or the protection campaign) the participants focused on" (Landmann and Rohmann 2020 p4). Being moved and anger were linked to collective efficacy, and involvement in the protest. A non-emotional response of perceived injustice was also important in collective action.

In a second study, Landmann and Rohmann (2020) manipulated the injustice and efficacy variables with videos. Three specially made videos about the Hambach Forest situation emphasised efficacy, injustice, or scientific facts (as the control). After watching one of the videos, 204 German psychology students completed scales covering anger, fear, and being moved, and willingness to join the protests.

Two paths to collective action were found. The injustice video produced anger and feelings of being moved which motivated the desire to punish those clearing the forest. The collective efficacy video produced feelings of being moved which led to the willingness to join the protest because together it would succeed.

Put another way, being moved by a cause has a positive side (the collective efficacy motivation of protest) and a negative one (to punish the apparent cause of the injustice).

"Anger did not predict collective action for forest protection well" (Landmann and Rohmann 2020 p9).

The relationship between being moved and protesting (or willingness to protest) was correlational. It was not possible to establish causality (Landmann and Rohmann 2020).

3.7.6. Encouraging Activism

Collective environmental action, including signing petitions and attending rallies, is facilitated by online platforms today.

Gulliver et al (2021) investigated the language used in online communications encouraging collective action by analysing 497 environmental advocacy groups' websites between December 2016 and April 2017. Linguistic software was used to categorise the words. The main categories were "collective identity" (eg: "we"; "friend"), "anger/injustice" (eg: "crying"; "worried"), and "collective efficacy" (eg: "success"; "strong").

Collective identity and efficacy terms were most commonly used on the websites. Emotion words were "comparatively rarely used" (Gulliver et al 2021 p7).

3.7.7. Fridays For Future Movement

The "Fridays For Future" (FFF) movement is based around school strikes to encourage the implementation of agreed climate goals of governments. Wallis and Loy

(2021) investigated the motivations of young Germans who joined the protests (n = 144 13-25 year-olds), and 418 contemporaries who did not. Various statements were used (table 3.5).

- "I feel a strong connection to others who engage in environmental and climate protection".
- "I feel proud to be active to protect the climate and environment together with others".
- "Together with others, I can make a relevant contribution to climate and environmental protection".
- "Human-made climate change is a serious problem".
- "I feel rage thinking about what the government and the economy are doing with regard to environmental and climate protection".

Table 3.5 - Examples of items used by Wallis and Loy (2021).

There were clear differences between the protestors and the non-protestors. The former identified with other protestors, perceived more pro-environmental activism by their friends, and so a stronger norm to participate. They were more concerned about climate change, but felt that their actions would bring about change (efficacy).

Identification with others who protest as a key motivation to activism fits with SIMPEA. Wallis and Loy (2021) ended: "Our results show that it makes sense to study collective aspects and personal pro-environmental norms simultaneously as drivers of pro-environmental behaviour, specifically when we wish to understand young people's activist engagement" (p9).

Note that the samples were convenience samples, the data were correlational, and only a limited number of items were used (Wallis and Loy 2021).

3.7.8. National Narcissism

Ingroup identification can lead to support for greenwashing when a country is showing this behaviour through national narcissism (NN) (the belief in national superiority or a grandiose image of the ingroup) (Cislak et al 2021).

Cislak et al (2021) reported five studies on this subject.

Study 1 - The participants were 173 undergraduates in Poland, who completed the "Collective Narcissism Scale" (Golec de Zavala et al 2009) (item eg: "If Poles had a major say in the world, the world would be a much better place"), the "Social Identification Scale" (Cameron 2004) (item eg: "I feel strong ties to other Polish people"), and a measure of political orientation. Support for an imaginary campaign by the government to promote the image of Poland to the world was the outcome measure.

High NN was associated with support for funding such a campaign. Note that neither national identification nor right-wing political orientation alone showed the consistent support for image enhancement.

Study 2 - The participants were 801 Polish adults who read a real story about the French Government criticising the Polish Government's refusal to introduction pro-environmental policies (yet claim to be a pro-environmental country). The outcome measure was support for the government campaign in Study 1, but the wording emphasised the "green credentials" of the country, and genuine pro-environmental policies. The other scales from Study 1 were also used.

Individuals scoring high in NN were more willing to support the image enhancement campaign than actual pro-environmental policies. "When the intergroup context is activated, those scoring high in national narcissism seem to be willing to defend the ingroup image, but they are less willing to support actual pro-environmental goals" (Cislak et al 2021 p6).

Study 3 - This study introduced an independent groups design with 200 Polish adults. Participants read about a campaign by the government to enhance the country's image as pro-environmental or actual pro-environmental policies.

High NN scorers supported the image enhancing campaign, but not pro-environmental policies, even when the policies were proposed by the government.

But the researchers worried that "participants might have assumed that image campaigns require less funding than a pro-environmental campaign (similarly as in Study 2). Consequently, the higher costs associated with pro-environmental actions might dampen the support for such campaigns compared to campaigns aimed at image protection" (Cislak et al 2021 pp7-8).

Study 4 - This study was the same as Study 3, but it was made clear that both campaigns cost the same. The participants were 199 Polish adults.

The previous findings were replicated, though support for the image enhancing campaign was lower if it was presented as costly.

Study 5 - Involving 1004 Polish adults, this online study offered more choices between image enhancing (greenwashing) and pro-environmental policies, and the outcome was measured on a scale rather than either/or. For example, participants could move a slider between "Introduction of a tax on burning coal" (1) to "Change of Poland's image as a country of smog" (11).

NN was again associated with support for image enhancement.

Cislak et al (2021) commented that the five studies suggested that "those high in national narcissism are determined to maintain the image of their national group as strong and worthy of respect... On the one hand, it seems simply easier to say that one's own country is ahead of others in environmental protection than to make a commitment to act pro-environmentally. On the other hand, compared to investing in natural environment, greenwashing attempts can more immediately satisfy the underlying needs for recognition and respect" (p11).

However, the researchers noted: "we do not claim that any type of strong national identity would oppose environmental goals, or exacerbate climate emergency. It is not merely strong attachment to one's own national ingroup that goes hand in hand with support for greenwashing..." (Cislak et al 2021 p12). This is important because the studies took place after the Polish Government had refused to sign a European "Green Deal" in 2019, while the President claimed that the country was "in the vanguard of actions for climate protection" (quoted in Cislak et al 2021). Previously, the government had allowed logging in the protected Bialowieza Forest, and in response to international protests, "granted a right-wing media outlet a large sum of money... to launch a website that would feature the Bialowieza Forest... The website, called puszcza.tv, streams pictures of the forest and features articles that imply Poland's superiority in environmental protection" (Cislak et al 2021 p1).

3.8. APPENDIX 3A - MEASURING PRO-ENVIRONMENTAL BEHAVIOUR

The use of scales to measure pro-environmental behaviour
"focuses attention on psychological antecedents rather than environmental impact of behaviour... [and] assumes that all the included behaviours are linked by a common psychological construct" (Nielsen et al 2021 p1). But there are infrequent choices, like vehicle purchase or decision about family size, where "non-psychological determinants are critical and for which environmental attitude is only a weak predictor" (Nielsen et al 2021 p1).

Another problem is the belief that "research findings can be generalised from one behaviour to another. However, studies repeatedly show that psychological factors predictive of low-impact behaviours are less predictive of behaviours of higher impact..., for which contextual factors beyond the individual are usually of greater importance" (Nielsen et al 2021 p1).

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4. MISCELLANEOUS GREEN-RELATED BEHAVIOURS

4.1. "POLLUTER ELITE"

The "polluter elite" are the top 10% of income globally, who responsible for half of carbon pollution emitted by households. This group includes all individuals who earn more than £25 000 per year ($38 000) (Nicholas and Steensen Nielsen 2021).

The carbon is released by these individuals in the following ways (Nicholas and Steensen Nielsen 2021):

i) Frequent and long-distance travel by plane and car.

ii) Home energy use.

iii) Where their money is invested (eg: pension funds invested in fossil fuel industries).

iv) How they communicate and behaviour with others (eg: social influence around environmentally friendly/unfriendly behaviours).

v) The actions they press for (eg: influence in the organisations to which they belong).

4.2. TRAUMATIC MEMORIES

Autobiographical memory includes first-hand experiences of events, and the second-hand experiences of hearing about events. This is particularly so with "flashbulb memories". These are "a special category of autobiographical memory, which is a type of personal and collective remembering of emotionally-charged and surprising events... This type of memory is suggested to be stronger, more enhanced, and vivid than other autobiographical memories containing detailed recollections of the incident at hand, such as the environmental context, people involved, sensory-

perceptual aspects and the precise time of hearing the news about the incident" (Knez et al 2021 p2).

Traumatic events can be the source of such memories. Knez et al (2021) studied a forest fire on 31st July 2014 in Vastmanland County, Sweden, comparing evacuated individuals (first-hand experience) and non-evacuated locals (second-hand experience). A sample of 601 adults living near the disaster are were recruited one year later (182 of them evacuees).

Questions were asked about the emotions then and now (eg: "When I think about the disaster today, I feel... Angry; Sad; Confused; Frightened; Vulnerable; Strong; Indifferent; Desire to fight back; Hatred; Outrage; Helpless; A need to give help; and Distracted"), autobiographical memories (eg: "When I think about the disaster today I often: reflect on it, talk about it (sharing), can in my thoughts mentally travel back to the disaster, and re-live it"), and personal consequences (eg: "My view of the world has changed because of the fire").

Factor analysis of the emotional responses produced three significant emotions - "anxiety", "rage", and "emotional strength", which varied between the recall of the event and the time of the questionnaire. Knez et al (2021) explained their findings: "Firstly, this indicates that the emotionally charged event of a natural disaster was emotionally more intense at encoding (first hours) than on retrieval one year after; secondly, that all three emotions of anxiety, rage and emotional strength were extracted at both occasions and are thereby part of the autobiographical memory in people living nearby the disaster area. Thirdly, the intensity of emotional strength was shown to be constant between encoding (first hours of catastrophe) and retrieval (one year after)" (p4).

Comparing the two groups, evacuees felt more anxious, enraged, and emotional strength one year later than non-evacuees. Evacuees also thought and talked more about the fire, and re-experienced it more than non-evacuees one year later. Evacuees felt their life more changed by the fire. "All this suggests that the psychology of dramatically charged events, such as natural disasters, differs notably between individuals 'being there' and those 'hearing the news', indicating a factual flashbulb memory as a result of the first-hand experience" (Knez et al 2021 p1) (table 4.1).

- 1 - Evacuees will have stronger emotional reactions to the event than non-evacuees.
- 2 - Evacuees will have better autobiographical memory of the event than non-evacuees.
- 3 - Evacuees will have higher levels of sensory re-experiences of the event than non-evacuees.
- 4 - Evacuees will feel that their lives have been changed by the event more than non-evacuees.

Table 4.1 - Four hypotheses tested and supported by Knez et al (2021).

Knez et al (2021) commented on their study design: "The non-equivalent comparison-group quasi-experimental design... used in this study might be considered to be weaker because it lacks random subject assignment... However, our respondents were randomly identified/recruited from a population register, and, according to Campbell and Stanley (1963...), there are 'many natural social settings in which the researcher can introduce something like experimental design … even though the researcher lacks full control over the scheduling of experimental stimuli'" (p7).

4.3. PLACE ATTACHMENT

"Place attachment" is "a positive affective bond between an individual and a specific place, the main characteristic of which is the tendency of the individual to maintain closeness to such a place", according to Hidalgo and Hernandez (2001) (quoted in Boley et al 2021). While Scannell and Gifford (2010) defined it as "a bond between an individual or group and a place that can vary in terms of spatial level, degree of specificity, and social or physical features of the place, and is manifested through affective, cognitive, and behavioural psychological processes" (quoted in Boley et al 2021).

Two elements of place attachment are "place identity" and "place dependence" (Boley et al 2021). The former is "the emotional or symbolic attachment formed with a place. Inherently subjective, place identity can operate as a component of personal identity whereby individuals define themselves through a given place... Place identity can grow from personal experiences that create meaning for an individual and instils in them

certain feelings regarding life or personal purpose" (Boley et al 2021 p2). Place dependence is where a place provides for an individual's needs and goals or satisfies motivations, and thus produces place attachment.

How to measure place attachment? The usual means is scale-based (eg: Brown and Raymond 2007 - seven items for place identity and seven items for place dependence). But the "lack of an internationally valid place attachment scale limits environmental psychologists from confidently including place attachment measures developed from a Western perspective in data collection within other parts of the world" (Boley et al 2021 p2) (table 4.2).

- Number of items in total and for the different elements.
- Western-based.
- Many items can be "redundant and even conceptually inappropriate" (Malhotra et al 2012 quoted in Boley et al 2021).
- Long questionnaires "'take more time to complete, tend to have more missing data, and have higher refusal rates than short surveys' [Stanton et al 2002]. Long surveys have also been recognised as problematic for studies prone to attrition and studies conducted online, where multi-item measures are hard to display... This is especially the case for surveys completed over mobile devices where the Likert scale matrices common with multi-item scales are not available, requiring excessive scrolling for respondents" (Boley et al 2021 p3).

Table 4.2 - Some methodological issues with scales to measure place attachment.

Boley et al (2021) outlined the "Abbreviated Place Attachment Scale" (APAS) with six items (three each for place identity and place dependence) (table 4.3) [17]. It was tested with a selection of cross-cultural samples in Poland, Cape Verde, USA, and Nigeria. The scale showed reliability and validity across the different samples (table 4.4).

[17] The original scale had twelve items.

Place Identity:

- I have a lot of fond memories of [named place].
- I feel [named place] is a part of me.

Place dependence:

- Living life in [named place] is better than living anywhere else in the world.
- There is no better place I would like to live in than [named place].

(Source: Boley et al 2021 table 1 p4)

Table 4.3 - Example of items from APAS.

- Content/Face validity - The items appear to be measuring what they claim to be measuring.
- Construct validity - Factor analysis of the responses of the different samples produced the same or similar underlying factors and factor loadings.
- Discriminant validity - Groups expected to be different gave different responses to the items (eg: residents vs tourists).

Table 4.4 - Examples of different types of validity of APAS.

4.3.1. Green Buildings

"Green buildings" are environmentally sustainable, but do individuals show place attachment to them?

Cole et al (2021) tried to answer this question in the absence of literature on the subject. They used the logic that "place attachment appears more likely in environments that support individual well-being" (Cole et al 2021 p3).

For example, biophilic design, which includes indoor plants, exposed natural materials, daylight, and views, have been found to reduce stress (Cole et al 2021).

One factor in place attachment may be "environmental identity". "Individuals with a strong environmental identity are most likely to form attachment via place identity in a building that they perceive aligns with their environmental values" (Cole et al 2021 p4). On the other hand, "individuals who do not subscribe to environmentally-relevant worldviews may not easily identify with a building that is branded as 'green', and would not be expected to form place identity in their green building" (Cole et al 2021 p7).

Green buildings have functions, like as a workplace, and the individual's attachment to their work ("workplace attachment") will influence their place attachment (Cole et al 2021).

From a practical point of view, green buildings that provide physical comfort (in terms of temperature, lighting, noise, and indoor air) will be more likely to elicit place attachment (Cole et al 2021).

4.3.2. Relocation to a Smart Office Building

"Smart (intelligent) office buildings" are "workplaces equipped with new technology, where interactive systems are supported by the internet, sensors and mobile devices... Smart office concepts are expected to work together with new workplace practices and characteristics, such as sharing workstations, activity-based workplaces, clean desk policy, and user applications" (Tuzcuoglu et al 2021 p1).

There is plenty of research on office environments generally, and on information and communication technology (ICT) in the workplace, but little on smart offices (Tuzcuoglu et al 2021). Smart buildings offer benefits like sensor data on user behaviour and presence which can minimise energy use (Tuzcuoglu et al 2021).

Tuzcuoglu et al (2021) studied the user experience when relocating to a smart office building in the Netherlands in 2018. Eleven semi-structured interviews were performed 5-12 months after relocation (table 4.5).

- What are the things you like most/least in the new office?
- What kind of expectations/opinions you had before you moved to the new office?
- Have you made any changes to the new office environment?
- How do you find this office considering a smart office concept?

(Source: Tuzcuoglu et al 2021 table 1)

Table 4.5 - Examples of questions in interviews.

Four phases of relocation emerged from the interviews:

i) Pre-location phase - From the announcement of relocation to the actual move, during which expectations about the new environment were important. "For instance, on an individual level, the satisfaction level with the previous office (and place attachment) seemed to create an expectation that the new office could provide at least the similar comfort level they had in the previous one. Meanwhile, the participants who were dissatisfied with their previous office environment appeared to be more excited when they learnt about the relocation. For them, this announcement may have promised a positive change and improvement. Some participants who had regular meetings in different buildings appeared to have neutral opinions towards the relocation announcement" (Tuzcuoglu et al 2021 p5).

ii) Confrontational phase - The first few days until the participant took an action (eg: changed something; made a complaint about an issue). "For example, some participants, who experienced a draught problem, hung an umbrella or placed cardboard as a temporary solution to minimise the problem until they received a permanent solution. Some also took temporary individual actions, such as changing workstation when having issues with the lights (either too bright or too dark) or temperature (feeling cold or draught from ventilation). On the other hand, some participants adopted new behaviours to work more efficiently, such as changing their schedule or shifting tasks to late afternoon to avoid distraction or leaving the office early to continue to work on tasks that require concentration" (Tuzcuoglu et al 2021 pp6-7).

The main words used were "chaotic, difficult, confusing, complicated, and crowded" (p5).

iii) Progressive phase - Until the participant had "a stabilised (ultimate) workplace appraisal" (p4).

iv) Stabilised phase - After "a stabilised workplace appraisal".

"Each participant experienced the process differently based on various extrinsic and intrinsic components throughout the process (eg: the day of the relocation announcement)" (Tuzcuoglu et al 2021 p4). However, four emotional trends were noted:

- Trend 1 - Higher excitement pre-location, but negative experiences in the new office.

- Trend 2 - Initially negative response, but became more positive pre-location and in the new office.

- Trend 3 - Mildly positive throughout.

- Trend 4 - Neutral response throughout.

The study showed that "the relocation to a smart office building and appropriation process of this type of office environment is similar to the other office types. Although smart office concepts indicate 'smarter' workplaces equipped with technology and thus better support its users, they appear to encounter the same appropriation issues and dissatisfiers (eg: noise) as other (non-smart) office types" (Tuzcuoglu et al 2021 p7). But the concept of a smart office also created expectations. Making clear to employees beforehand what "smart office" means would be useful (Tuzcuoglu et al 2021).

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5. SUSTAINABLE BIOBANKING

There has been an argument forwarded for an "environmental turn" in bioethics, which "considers individuals, populations, and environmental factors in understanding (health) practices and policies... This environmental turn also aims to broaden the bioethical discussion to include issues about community, social responsibility, solidarity and justice. This endeavour has been variously labelled public health ethics, environmental health ethics, green bioethics, population ethics or global ethics..." (Samuel et al 2022 p51) (appendix 5A).

"Sustainability" is a key concept here. This was defined by the World Commission on Environment and Development in 1987 as "using resources in a way that allows resources to continue to exist for use by others" (Samuel et al 2022 p51). But critics like Rolston (2002) described it as a "grand policy, asserted with vigour, and then weakened with a thousand diverse applications and analyses, leaving nothing much to do in focus" (quoted in Samuel et al 2022).

However, making sustainability a normative principle is important, and Samuel et al (2022) applied this to "the ethical issues related to the environmental sustainability of data and digital infra-structures in global health research systems that inform healthcare" (p52) (eg: the electricity consumed to power and cool equipment in large data centres; the extraction of minerals used in digital technologies).

Human biobanks collect, process, store, and distribute both health data, and physical samples (eg: UK Biobank; FinnGen (Finland); Biobank Graz (Austria)) (Samuel et al 2022). These large-scale research resources fit the "big data" approach to health.

Watson et al (2014) outlined three "pillars of sustainable biobanking" (Samuel et al 2022):

i) Financial sustainability - eg: operational costs. The UK Biobank has recruited a cohort of half a million people including their biological samples that need to be stored in freezers.

ii) Social acceptability - eg: accepted practices and standards to the research community, the public and patients, and other stakeholders.

iii) Operational sustainability - "to ensure policies and procedures improve the quality of

biospecimens and increase the efficiency of biorepository operations in terms of input, internal and output components" (Samuel et al 2022 p55).

Samuel et al (2022) argued that the sustainability of biobanks should address "the entire life cycle", and focus on social justice ("ensuring the equal allocation of burdens, risks, benefits, and opportunities that may come from development within all societies"; pp55-56). In other words, broaden the concept of biobank sustainability. This could be done in different ways, including establishing an agreed way to define and assess sustainability, and how biobanks can take responsibility. For example, "while advances in sequencing technologies have resulted in the sequencing of entire genomes of participants (where previously only tiny fractions were analysed), it may now be appropriate to consider whether sequencing and storing genomes that are more than 99% identical in all humans holds significant advantages and whether there are environmental costs in doing so" (Samuel et al 2022 p56).

APPENDIX 5A - ENVIRONMENTAL BIOETHICS

"Environmental bioethics" covers the idea of sustainable health care policy (eg: encouraging carbon-neutral travel like walking and cycling; eliminating animal-based foods from hospital menus; reducing wastage in health care facilities) (Richie 2020).

In the UK, carbon calculations have been made of health care buildings, and of individual medical procedures (eg: heart bypass operations; haemodialysis; caesarian sections and vaginal childbirth) (Richie 2020). Other initiatives include reducing single use plastics, decreasing the use of certain anaesthetic gases, and the prescribing of pharmaceuticals (Richie 2020).

Richie (2020) introduced a special issue of the journal "The New Bioethics" which addressed environmental bioethics from different angles:

i) Theoretical - Papalois and Papalois (2020) drew a parallel between the human body and the planet based on the concept of homeostasis, which "describes the human body's intrinsic tendency towards equilibrium. A change in one direction elicits a response in the opposite direction, restoring harmony. An excessive shift results in a change that cannot be compensated. This imbalance results in illness" (quoted in Richie 2020).

ii) Practical - Ghersin et al (2020) described their attempts to reduce waste in their paediatric intensive care unit in a US hospital. Richie (2020) explained that "[W]hile hospital policies on 'medical waste' are appropriately based on safety standards, there is little reflection about alternatives which maintain sterility and reduce the carbon footprint of health care. The authors note that medical personnel 'must find ways to balance the professional duty to prepare with the professional duty to limit the negative impact practices have on the environment, and to save resources when able'" (p85).

Kemple (2020) argued that this imbalance is an obligation of doctors. "Recipients of medical care must be given the best care, not only at the moment of need, but also in the long-run" (Richie 2020 p86).

Gurevich (2020) wanted initiatives to go beyond the hospital (literally and metaphorically), which include the idea of "eco-therapy", "which immerse individuals with mental and physical health conditions in nature, and green health centres, which integrate conservationist practices into the daily life of a hospital" (Richie 2020 p86).

While Macpherson et al (2020) proposed three wider goals for health care providers, professionals, and those involved in the "medical industry" - slowing the global birthrate, transforming the food system, and genetically modifying mosquitoes.

Storz (2020) argued for vegetarian and vegan diets as a means to reduce and prevent disease, as well as benefiting the planet.

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6. MARINE ECOSYSTEMS

6.1. THREATS

The leader (2022) warned that the "problems of the oceans are often overlooked in our focus on our depredations of the lands" (p5). Yet the "blue acceleration" is happening, where "mineral exploration, shipping, energy, tourism, desalination, cable laying, bioprospecting or more, ocean-based industries are picking up speed fast" (Lawton 2022 p38).

The threat to marine ecosystems can be viewed through three themes (Schmidt and O'Donnell 2022):

i) "Trajectories, challenges and solutions for biodiversity" - "Most areas of the deep ocean is under the stewardship of countries with developing economies" (Schmidt and O'Donnell 2022 p2). This has implications with the cost of nurturing marine ecosystems.

Risks to animals includes higher rates of land-based run-off (eg: contaminants). "Persistent and mobile contaminants bioaccumulate in the ecosystem, with potentially severe consequences for reproduction, health and metabolism of marine mammals" (Schmidt and O'Donnell 2022 p2).

ii) "Challenges and opportunities for the blue economy" - eg: in "small island-large ocean states" like atolls peoples in the Pacific.

iii) "Adaptation and mitigation challenges for ocean states in the era of climate change" - eg: the creation of "marine protected areas".

6.2. ATOLLS

Barnett et al (2022) described atolls as "dynamic environments that are highly exposed to impacts from climate change" (p1). The majority of these "shallow coral platforms that grow on top of submerged sea-mounts"

(p2) are found in the Indian Ocean (56 atolls) (eg: Maldives) and the Pacific (367 atolls) (eg: Kiribati) (Barnett et al 2022).

Concern relates to their habitability, which means "the conditions under which people are able to lead dignified and meaningful lives characterised by satisfactory human development, livelihoods, and well-being" (Barnett et al 2022 p1).

Rising sea levels is the key concern, but there are also anthropogenic problems in urban atolls (eg: pollution, mining, shipping).

In dealing with the risks, "nature-based solutions have been the norm in atolls for a long time, with modern engineering instead being the exception" (Barnett et al 2022 p4) (eg: planting trees). "Reef restoration" is a possibility, which involves "out-planting corals or coral fragments on reefs or assisting coral recruitment through various means, such as substratum addition, enhancement or stabilisation" (Barnett et al 2022 p5). Importantly, healthy reefs are "more likely to accrete upwards in response to sea-level rise, and to be more resilient to temperature extremes" (Barnett et al 2022 p5). Ferrario et al (2014) estimated that coral reef restoration was significantly cheaper than the cost of the construction of artificial breakwaters.

Mangrove conservation, seagrass cultivation, and revegetation of bare land areas are other nature-based solutions (Barnett et al 2022).

6.3. FOUNDATION SPECIES

"Foundation species" are key in all ecosystems. They are "generally abundant enough to directly and indirectly connect to many more species than other species in an ecological network, particularly those using coastal environments that typically provide vital food sources for both land and ocean predators. Coastal environments are highly threatened by exposure to both ocean- and land-based human pressures, as well as future climate change" (Tulloch et al 2022 p1).

In the coastal environments of western North America two foundation species are the Pacific salmon and the Pacific herring. "Marine mammals depend directly on Pacific salmon for food, while land mammals rely on adult salmon as a key food source upon their return to freshwater rivers. Migrating juvenile salmon or spawned-out adult salmon carcasses are important annual prey sources for a broad array of species in freshwater and

terrestrial systems. The salmon predator–prey system helps distribute marine nutrients from salmon flesh into land ecosystems through direct carcasses deposition or scat and urine deposits from predators... Juvenile and adult herring are critical prey for open ocean and nearshore predators, while shoreline spawning events also support an array of predators and scavengers through pulsed aggregations of fishes and lipid-rich eggs that benefit seabirds, landbirds, marine mammals, land mammals and inter-tidal invertebrates" (Tulloch et al 2022 p2).

Tulloch et al (2022) undertook a case study of the impact of human activities in marine environments on these two species in the Central Coast region of British Columbia. The marine activities included fisheries, marine tourism, oil and gas exploration, and large vessels, while the land-based pressures included forestry, land tourism, and population centres.

Based on a literature review and expert consultation, a risk model was created. Human activities had the greatest risk for salmon. "The pressures with the highest cumulative risk for salmon and herring were associated with forestry activity for land (pollution from forestry effluents (ie: sedimentation), and estuarine/inshore habitat disturbance respectively), with commercial fisheries ranking the highest for marine activities" (Tulloch et al 2022 p8). The inclusion of climate change pressures increased the risk.

The analysis showed that indirect impacts (ie: land-based human activities) were as important, if not more so, as human marine activities for these two foundation species, and thus the whole ecosystem (eg: disproportionate impacts on predators).

The researchers described the impact of humans on the ecosystem as the "death by a thousand cuts" (Tulloch et al 2022 p1). A total of twenty human activities were noted with over seventy different pressures on the ecosystem.

6.4. BLUE FOOD

The global food system generally is responsible for around one-quarter of all greenhouse-gas (GHG) emissions, while millions of people lack sufficient food and millions more are overweight or obese (Gephart et al 2021).

"Blue foods" could be an answer to hunger and food insecurity, and to GHG emissions. Blue foods include fish and shellfish, as well as "the diversity of animals,

plants and algae harvested from rivers, seas and the ocean" (Editorial 2021 p303).

In terms of nutrients, like vitamin A, calcium, and zinc, many fish species are richer on average than beef, lamb, chicken or pork (Golden et al 2021).

Also some farmed aquatic foods (eg: shrimp; oyster) can have lower GHG emissions than foods gathered or caught in the wild (Gephart et al 2021).

Gephart et al (2021) calculated the GHG emissions for twenty-three species groups of farmed blue foods. The authors, while promoting such foods, accepted that their "findings do not suggest unlimited blue food growth is possible nor that expansion comes without environmental trade-offs. Furthermore, without careful consideration for local contexts and inclusion of relevant stakeholders, environmentally focused interventions can generate social and economic trade-offs that underline broader sustainability goals. Nevertheless, farmed blue food is among the fasting growing food sectors and the global community now faces a unique window of opportunity to steer expansion towards sustainability" (Gephart et al 2021 p364).

Golden et al (2021) modelled increased seafood production in the next decade, and showed the benefits in lowering macronutrient deficiencies. The modelling, however, made a number of assumptions (eg: seafood export and import by countries) (Lauritzen 2021).

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7. FUTURE OF THE BIOSPHERE

"Regional, continental and planetary-scale changes are taking place at an accelerated pace. Greenhouse gases are the most obvious example of such a trend, with CO2 in particular displaying a fast increase that has no equivalent over the past 500 Myr" (Sole and Levin 2022 p1). Predicting how these changes with exactly play out is of interest.

This is done through modelling. Meadows et al (1972), for example, is a historical example of long-term prediction based on key variables, including human population, food production, industrialisation, pollution, and the consumption of non-renewable natural resources. They stated that "the limits to growth on this planet will be reached sometime within the next one hundred years" (Meadows et al 1972 quoted in Sole and Levin 2022).

Modelling today includes "consideration of the explicit role played by climate. As global warming and an intensive exploitation of planet resources keep rapidly increasing, the analysis of past climates and modelling efforts suggest that future changes can unfold in potentially catastrophic ways. As far-from-equilibrium, dissipative structures, ecological systems exhibit non-linear dynamical properties that pervade their stability but are also responsible for their fragility under stress. They are in fact complex adaptive systems (CAS) [Levin 1999]" (Sole and Levin 2022 p3).

The upshot is a complex systems perspective on the feature of the biosphere. Sole and Levin (2022) took 2050 as "a potential time horizon" to summarise some of the key issues:

i) Non-human species extinction due to the growth of human populations with the expansion of agriculture and the domestication of animals. The expansion of agriculture "fostered a hyper-exponential growth. In the language of complex systems, agriculture represents a major transition: the emergence of ultra society [eg: Gowdy and Krall 2014], which allowed us to reduce environmental uncertainty" (Sole and Levin 2022 p4).

Solutions include the reduction of birth rates, and the protection of large areas of wild habitats (eg: "Half Earth"; Wilson 2016) (table 7.1).

The biodiversity-ecosystem function includes "services" that act as "life-support systems for humanity", though often ignored or taken-for-granted -

- "30 by 30" is a scheme whereby each nation agrees to set aside 30% of its land and sea for nature by 2030 (to create "pristine biodiversity") (Lawton 2022a).

Lawton (2022a) noted some concerns with such schemes, including:

- i) Lower-income countries which are biodiversity-rich wanting compensation for limiting their economic development (eg: the Amazon and Brazil) [18].

- ii) Preserving the right areas as pristine biodiversity is not evenly distributed throughout the world. Some countries do not have "enough" biodiversity for 30%.

- iii) Treaties that allow loop-holes (eg: "false accounting" where managed forests are counted as pristine biodiversity).

- iv) The impact on Indigenous peoples who live in places designated protected areas.

Table 7.1 - "30 by 30".

ie: "millions of years of plant and phytoplankton cumulative photosynthesis; the tens of millions of soil organisms that transform dirt into fertile soil, decompose the bodies of dead organisms and contribute to nutrient recycling; the wild and domesticated plants, animals (both terrestrial and aquatic) and fungi that for millennia have fed and currently feed the human population (ie: we all eat biodiversity); the communities of animals that maintain plant reproduction and genetic diversity, as well as those animals that regulate the abundance of disease hosts and vectors; the thousands of plants, fungi, other micro-organisms and animals that have provided and continue to provide medicine or medicine models; the physical protection due to ecosystem 'structures' such as mangroves and coral reefs from extreme weather events; and the increasingly appreciated significance of the inspirational, educational and emotional benefit derived from our contact with biodiversity..." (Dirzo et al 2022 pp3-4).

ii) Resilience and tipping points - "Future changes in ecosystems under Anthropocenic driving forces are likely to be non-linear. Non-linear responses are a common property of all CAS (from biology and ecology to

[18] "Biodiverse countries are often GDP [Gross Domestic Product]-poor, and many don't see why they should be forced to remain so in order to rescue wealthy nations from catastrophe" (Lawton 2022b p28).

social and economic systems). These systems are often characterised by the presence of multiple alternative states, and in many cases transitions from one state to another are expected to be abrupt" (Sole and Levin 2022 p4).

Coral reefs are a good example, where "a perfect storm of non-linear effects have changed these highly diverse ecosystems. A combination of human-dominated actions along with Allee effects [19], habitat loss and fragmentation along with pollution and overfishing and extreme events has been devastating" (Sole and Levin 2022 p5).

The problem for modelling is predicting when tipping points and sudden shifts will occur. One possibility is the use of "warning signals" (ie: "statistical patterns of fluctuations that are expected to occur close to critical points"; Sole and Levin 2022 p6).

Dirzo et al (2022) agreed: "Predicting the exact trajectory of a complex adaptive system is near impossible but predicting one that will have emergent properties is generally correct. Changing the atmospheric temperature will certainly change the functioning of a terrestrial ecosystem, but just how is much more difficult to predict" (p3).

An early warning sign of "forest dieback" (ie: where rainforest turns to savannah) could be the temperature difference between seasons (Wilkins 2022). Parry et al (2022) showed that as the gap between the highest and lowest temperatures grew larger, so did dieback in the Amazon in Brazil, Colombia, and Peru.

"Observations from satellite data have already shown that the Amazon has been becoming less green over the past two decades, which could be a sign that the region has become less able to restore itself to a stable state after being affected by events like wildfire or drought" (Wilkins 2022 p23).

Dirzo et al (2022) gave the example of rainforests in Veracruz, Mexico, where "deforestation and fragmentation singly reduce the amount of suitable habitat needed to maintain viable populations of large animals (an indirect effect), therefore leading to wildlife declines and eventual loss of the local populations of large vertebrates. However, such deforestation and fragmentation also facilitate overexploitation (a direct effect) via the access of poachers to sectors of the habitat that previously were inaccessible — a synergy that drives the local

[19] Describes the relationship between population density and individual fitness (ie: "under-crowding").

extinction of medium-sized and large mammals (in turn affecting multiple interactions between wildlife and plants)" (pp2-3).

iii) Responses - The combination of responses at different levels (from species through to global).

"A less explored path involves the bioengineering of ecosystems by means of synthetic biology and other strategies aimed at the modification of genomes or microbiomes. This has been traditionally a controversial approach due to the concerns raised by the possible unintended consequences of manipulating organisms and in particular their delivery in natural environments" (Sole and Levin 2022 p8).

Dirzo et al (2022) offered four actions to slow down the rate of extinction of species:

a) "Telling it like it is" - "It is notable that, while climate change has drawn the spotlight, the biodiversity crisis has comparatively received appallingly little attention" (Dirzo et al 2022 p5).

b) "Safeguarding what is still present" - "Although the damage to biodiversity is considerable, we still have a few relatively unscathed remnants in the natural protected areas of the world and, to some degree, in some human-dominated landscapes. Since a large portion of such remnants of biodiversity is present in Indigenous and rural territories, recognising, supporting and materially compensating those populations is a matter of utmost importance. In addition, safeguarding those Indigenous territories is critical to retain the traditional ecological knowledge and languages that are being profoundly eroded from these communities across the world" (Dirzo et al 2022 p5).

c) "Moving towards an ecologically friendly human diet" - eg: "Less meat can translate not only into less heat, but also more space for biodiversity and betterment of human health" (Dirzo et al 2022 p5).

d) "Combat kakistocracy" - Kakistocracy is government by the least able or appropriate people.

Sole and Levin (2022) ended that "predicting the future might be difficult, but we can also think out of the box. Our species has been a too successful ecosystem

engineer, transforming a planet where ecosystems are nowadays being dismantled. We face an uncertain future with limited resources exploited by a fast-growing human population and where biodiversity needs to be protected. Biodiversity is central in providing society with the required goods and services to sustain itself. Action is needed to preserve it while ensuring the well-being of humans" (p9).

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