The importance of time frame in tackling new and emerging crime problems: The Co-Eco, Devo, Evo Framework

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Background

- Been working on evolutionary approaches to crime/security technology and techniques since mid-90s – latest a study of **Provisional IRA weapons** (with Paul Gill)
- A current project has taken me deeper and more systematically into the evolution of crime in the **cyber** domain
  - Project **ACCEPT** aims to apply a co-evolutionary approach to cybercrime, and in particular to consider the whole system of **humans plus technology**
- I'll be offering insights from this work – but not heavy cyber jargon!
- The ideas are still evolving with the collaboration of colleagues, and still a bit abstract
- Hope to get some feedback

Crime & Security – too Static a View?

Evidence-based approaches seeking '**What works**', assume that works now, will continue to do so indefinitely

Situational Crime Prevention research suggests crime **displacement** of only limited significance – solutions are 'once-and-for-all'

But most studies have focused on trends/outcomes in the **short-term**, domains, e.g. burglary, where there has been **little technological change** over relevant timescale, & where offending often **opportunist**

Few **Situational** approaches view offending over a person or OCG's career

Security approaches often acknowledge '**crime as moving target**' but don't systematically address this

I aim to move security thinking into a more **dynamic** place, emphasising **change**

I draw on **Biology**, **Systems** approaches and **Cultural Anthropology** to articulate the understanding of **problems**, focus **research questions** and sharpen **solutions**

Significant Examples of Dynamic Crime/Security Problems

- Card theft
  - **Chip-and-pin** card security a significant success at first, but diminished in light of contactless transactions; then we saw **3D printing** of fake card-scanning slots on ATMs; **online sales** entirely bypass card-based security
- Car theft
  - Sustained drop due to improved security (**immobilisers** etc) now waning as we see **burgling for keys**, misuse of **wifi extenders** transmitting key signal from house to car
- Terrorism and organised crime
  - Persistent, highly-motivated, unfazed by tactical defeat, involve acquisition of resources, outsourcing, R&D
- Cybercrime
  - **Rapid development and dissemination** of opportunities, techniques, countermeasures
  - **Hyperconnectivity** means annihilation of practical constraints of distance, and very different ratio of effort/scale in relation to reward
  - **Internet of Things** – exponential growth – heading for 50bn connected items
  - **Crime As A Service** on Dark Web

We Therefore Need Solutions that are:

- **Dynamic and adaptive** rather than static
  - Out-innovating adaptive offenders against a background of technological and social change which favours first the one, then the other side
- **Anticipatory** rather than reactive
  - The future won't be 'more of the same' – changes may be nonlinear
- **Varied** – to fit diverse contexts & challenge offenders with new problems
- **Intelligently scalable**
  - Slavish replication of success stories often followed by implementation failure in different contexts
- **Able to handle complexity** & **complex adaptive systems** – agents with diverse motivation & resources adapting to and anticipating each others' moves
  - Simple crime triangles, cardboard cut-out rational offenders and a hotch-potch of poorly-integrated perspectives aren't good enough
- Sensitive to different **time frames** over which crime and security are **enacted**, and over which they **change**

Candidate Time Frames

1. **Here-and-now** – normal focus of Situational Crime Prevention and Law Enforcement

2. **Career**

   – Of individual **agents**, whether **individual offenders**, **organised crime groups** or professional **preventers**, as they acquire repertoires of **actions, techniques and technologies**

3. **Change across generations and populations**

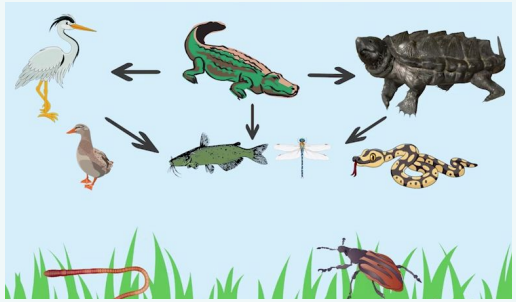
   – Of people and groups

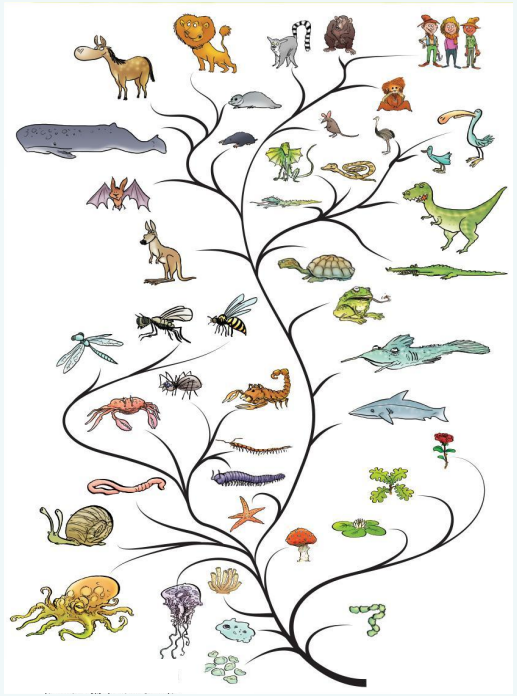
   – But also of procedures, services, material products & places, and info technologies

We must address **all** these time frames, the better to deal with **present** problems and to **anticipate** future ones, and handle their **dynamic nature**

Eco, Devo, Evo

- To make the most of these time frames we can borrow from the **Life Sciences** to respectively distinguish
  - **Eco** – ecology and ecosystems
  - **Devo** – development and learning
  - **Evo** – evolutionary and co-evolutionary



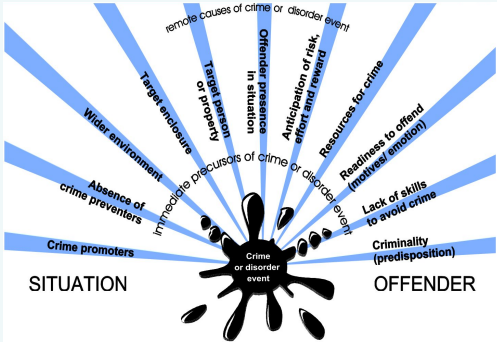


Eco, Devo, Evo

- These frames can be translated into
  - Human **performance**, **learning** and **cultural** evolution
  - Also the **technological** equivalents covering **operational** products, places and systems; those under **development;** and the **succession of versions and innovations** unleashed on the market
- **Not** implying a **universal time scale** here – for example, Evo in cybercrime may be faster than Devo in offender careers

Time Frames – ECO

- Eco covers the here-and-now **ecological interactions** of **agents**
  - **Within their environment**, attacking or defending a target of crime, and conflicting or collaborating with each other (offenders and preventers)
  - Agents seen as **performing** with their **existing repertoire** of behaviour and resources
    - To acquire **tactical info** on immediate contingencies (eg hostile reconnaissance),
    - To **respond** to tactical **opportunities**, **forage** for them or actively **create** them
  - Agents also **respond** to **precipitators** (prompts, provocations, permissions, pressures) and set them up for others to experience
- Preferred framework covering offenders, other agents and material or human targets in the immediate environment – **Conjunction of Criminal Opportunity**
- CCO integrates all the crime science perspectives in a one-stop shop, though it's not the last word – needs to with wider ecological/social perspectives, more distal causes



Time Frames – ECO – Nature of Agents

- Important to get the concept of **agents** right
- People/ groups/ organisations can be viewed as '**Caused agents**' who are both caused and causing:
  - **Caused:** prior predisposition, perceptual tendencies, motivation, precipitation
  - **Causing:** engendering events through their actions on basis of **goals, plans, decisions, affordances** – perceived utility of people/ things in their environment
- Focus here is mainly on the active, **causing agent** perspective
- Agents nowadays include **autonomous ICT** with **AI/Machine Learning**

Time Frames – ECO – Agents and Roles

- Agents take on **roles**
  - **Crime**: Offenders, Preventers, Promoters, Victims, Responders
  - **Civil**: User, Resident, Employee, Passer-by…
  - They **overlap** between and within these 2 categories (victim can be preventer, employee can be promoter, offender)
- The crime (and also the civil) roles **interact** with one another, and with the immediate **environment**
  - Incidentally, via **routine activities** and **geometry** (crime generators)
  - More **deliberately** (seeking crime attractor places/ avoiding detractors)
- From a **systems perspective** there is some symmetry between the good guys and the bad
  - A crime preventer's **problem** is an offender's **opportunity**, and vice-versa

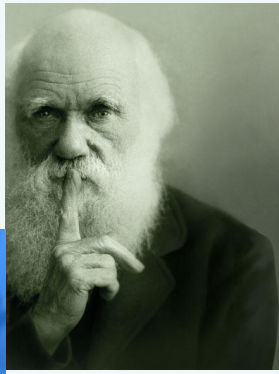
Time Frames – DEVO

- Devo covers changes undergone by agents or things **within** a **lifetime**, a (criminal) **career** or a **generation** –
- I.e. those that endure beyond the individual criminal event/ situation
- Devo changes occur through various mechanisms, eg:
  - Operational **feedback** from success or failure of agent's own actions (*this* action reliably bypasses the car alarm)
  - Individual **imitation** and other forms of **social learning**
  - **Cultural acquisition** of values, attitudes, goals and techniques
  - **Organisational development** & growth of membership, operations

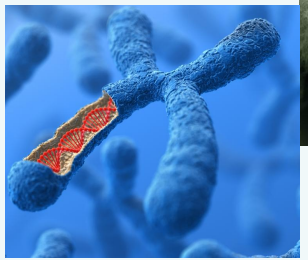
Time Frames – DEVO – Technology

- We must also consider developmental changes undergone by **technology** – broadly taken to include **product, place, system, procedure or intervention** – during the working lifetime of individual items
  - **Customisation** during/after manufacture (e.g. boosting security properties in anticipation of exposure to increased risk)
  - **Programming**/self-programming (as with smartphones that learn your preferences)
  - **Modification** (eg hacking in the constructive, repurposing sense; adding security features in light of increased risk)
  - **Updates and upgrades** (not just ICT – 'How buildings learn' book)
- All this is about making products/procedures/systems adjustable during development and operation so they can be **customised to context**, and to adapt to **changes** in that context – biological term is **developmental plasticity**

Time Frames – EVO



- Initially inspired by ideas from **biological** evolution
  - Original Darwinian processes of **variation, selection, transmission/ replication/ inheritance**
  - ‘Modern Synthesis’ of Darwin + genetics, viewing evolution as changing frequencies of gene variants (alleles) or traits in a population of organisms
  - More recent – ‘Extended Evolutionary Synthesis’ – later



- But biological evolution is a **highly-structured** process (genes, chromosomes, mitosis/meiosis/sexual reproduction)
- More recently, big developments in concept of **cultural evolution** in biology and anthropology – covering social and technological change – so I primarily draw on this
  - Cultural evolution shares similar **algorithm** to biological, albeit one that is looser and more debatable (controversy over **memes** as ‘cultural replicators’ equivalent to genes)
  - Cultural evolution exists in other animals but far stronger in humans because of **high-fidelity copying** (language, writing, mass-production, ICT; copy-process-not-product)

Evo – Global Perspective – Populations

- Need to take closer look at some of the key concepts
- Changes, variations in **traits** e.g. height or hair colour, occur in a **population** over successive **generations**
- **Population** refers to the **units** that are evolving
- **Units** can comprise
  - **Individual agents** in particular **roles** (e.g. offenders, preventers), **OCGs**, police/security **organisations**
  - **Actions/things** – perpetrator techniques/crime scripts, goals and plans, ICT operating systems or applications, sensors, tools and weapons
    - Here there might be literal lessons from evolutionary biology e.g. on emergence of body armour
  - **Groups** – these introduce special and controversial issues of **multi-level evolution and reproduction** (genes > cells > organisms > groups/organisations)

Evo – Global Perspective – Generations & Levels

- **Generation** is usually clear in biological evolution, but a difficult concept in cultural/technological evolution
  - One iteration of a design or one version of software doesn't reproduce itself as the next generation, but is **artificially created**, taking in info from predecessor and elsewhere,
  - This often happens in an **evolutionary microcosm**, protected in the designer's workshop from market forces, until launch
  - Straight **copying** of images, software, 3D printing of products including tools/weapons probably doesn't count (probably akin to cloning, e.g. taking cuttings from favourite apple tree)
- Generation is difficult too with **group-level**
  - Do **OCGs** ever bud off subgroups, or even undergo the equivalent of sexual reproduction (mergers then splits)?

EVO – Cultural Evolution – Basics

- From a cultural perspective, trait **variants** (e.g. alternative **MOs** or **security interventions**) are
  - **Generated** through **innovation** or simple serendipitous **copying error**
  - **Selected** e.g. on basis of **success/failure**
  - **Replicated** through various forms of **transmission**
  - And the successful variants become more **prevalent** in the population

EVO – Cultural Evolution Basics – Selection

- Over generations, selection of **fittest** variants & inheritance of their properties leads to
  - **Adaptation** of the **population of cultural traits** to their environment, enabling survival, flourishment and replication in the material, social and informational world and
  - Perhaps forming a particular **niche**

EVO – Cultural Evolution Basics – Selection

- Selection works by people choosing to
  - Copy a **successful action** or
  - Copy the actions of **successful people/organisations**
- In security, note the importance of **evaluation**, and the cultural trait of **evidence-based policy/practice**
  - These apply and maintain a discerning **selection pressure** on security interventions
  - Through **outcome** criteria, they sharply define the 'fitness function', to judge the interventions by
- Note that **external factors** continually change the **environment** (eg fluctuating commodity price of copper) so adaptation of criminals (or security) is never maximised/ finished

The Niche

- Niche is an evo concept – a combination of properties of the **agent** and of the **environment** – a kind of ‘professional job description’
  - E.g. wolf spiders with long legs, adapted to hunting among leaves on forest floor
  - Criminals with financial/social skills, adapted to fraud, capable of exploiting fraud opportunities and coping with the risks
- Arresting individual offenders/disbanding OCGs may not work if the **niche** for offending is allowed to persist – **offender replacement**
- Niche has counterparts at other timeframes
  - **Eco** – **opportunity** to pursue what **goal**, with what **resources**, in what **environment**
  - and **Devo** – what **career slot** can an offender pursue or construct, acquiring and deploying what **resources** in an environment with what **opportunity structure**

EVO – Cultural Evolution Basics – Transmission/Replication

- **Cultural transmission** is more complicated than its biological counterpart:
  - **Vertical** (parent-child)
  - **Horizontal** (peer-to-peer)
  - **Oblique** (e.g. from some experienced person other than parent)
  - **Broadcast** rather than 1:1 or 1:few e.g. over Internet
- Transmission mechanisms include
  - **Imitation**
  - **Recommendation** sites (both can generate **fashions** or **contagion** in crime, security)
  - **Teaching** (Evo) which connects with **learning** (Devo) by individual recipients of the culture
  - **Dissemination of tools and exploit kits** e.g. with generation of computer viruses on Dark Web
  - **Collaboration/co-offending** to pool labour, specialist knowhow
  - Provision of **crime as a service** e.g. ransomware helpdesk etc

EVO – Cultural Evolution Basics – Transmission

- In genetic inheritance, **genes** are **recombined** as clearcut ‘independent’ factors (Mendel’s pea experiments) which largely remain unchanged over generations
- In cultural transmission there is often **blending and (re)construction** of multiple ideas in the information received by each generation – so in many cases, original idea is replaced by new forms which then become transmissible/ blendable in turn
- In Crime Science, **Scientific Realist** accounts of evaluations look at replicable **principles/mechanisms** and **practices** which support the process of **constructive development** and **generation of variety** rather than **slavish copying** and roll-out at scale of what worked once, in one time and place

Evo – Acceleration and Boosting Efficiency

Some things accelerate evolution and boost its efficiency

- **Numbers of evolvers** trying out mutations over long periods
  - Trillions of bacteria trying out new ways to infect hosts
  - Thousands? of disenchanted sales staff watching for vulnerabilities in cash registers
- Ability to **share innovations**
  - Pathogens sharing genes that boost infectiousness or virulence,
  - Humans sharing ideas on Internet
- **Intensity and focus of selection** pressures, especially predation
  - Boosts splitting of an existing species into multiple ones
  - Might predation by police engender different criminal specialisms?

Evo – Evolution of Evolvability

- Evolutionary systems discover (then transmit) ways of speeding up the **generation of potentially successful adaptations** – like business process re-engineering to boost innovative capacity

- In biological evolution, mix-n-match of **sexual reproduction** arguably evolved to keep innovating resistance mechanisms faster than **parasites** could learn to overcome them

- And the development of **modular body-plan** genes has enabled advanced life forms to generate a huge variety of new physical shapes that are **functionally plausible**, with few complete duds

Evo – Cultural Evolution of Evolvability

- In cultural/technological evolution we can boost evo of evolvability
  - Encouragement of **variety, design freedom and performance criteria** in the specification and design of security measures such as locks can avoid the ‘crack one, crack all’ issue
  - A combination of **organised, tested theoretical principles** and **modular, recombinable practice elements** can help practitioners generate **plausible innovations** that have a good chance of working first time
  - An explicit process of **design, development, testing, monitoring and adjustment** of products, places, interventions can select and refine these innovations
  - Making products/procedures/systems **adjustable** during development and operation so they can be **customised to context** – **Developmental plasticity**
  - **Sharing and cross-fertilisation** of knowledge and ideas
- Ideally want to **boost evo for security** but **retard it for offenders**
  - Eg ‘**security by obscurity**’

Taking the Brakes off Eco, Devo, Evo

- Arrival of the **Cyber** world has removed **constraints** on agents in all 3 timeframes
  - **Space** – distance has been annihilated, spatial coverage freed up by hyperconnectedness, Cyber connections pervasive
  - **Time** – Cyber acts faster, changes faster
  - **Material** – Cyber dematerialises many actions, assets, barriers
  - **Cost/effort-to-reward** ratio – scaling up is cheap
  - Coding means many constraints are no longer a matter of physical necessity, but one of **convention or choice**
- Cyber increasingly penetrating the **material** world
  - Sensors, industrial control systems, augmented reality, 3D printing
- **Drones** have also removed constraints within material world
  - Add 3rd dimension to agent mobility, enable telepresence through perception/action, overcome barriers

Co-evolution – Arms Races

- **Offenders** and **preventers** each constitute part of the others' **environment**
  - As noted, one party's **opportunity** can equate to other party's **problem** and vice-versa
- In an **Eco** timeframe, we can have short-term playing out of **move and countermove** taken from each agent's existing repertoire
- In a **Devo** timeframe, we have **reciprocal learning** – particular adversaries can find out about one another's capabilities and sharpen up their own local, **situational countermoves** (displacement)
- In an **Evo** timeframe, where this is protracted and cumulated over generations of products and practices, we have **reciprocal adaptation**
  - The adversaries each provide what can be **highly-targeted, intense and persistent selection pressures** on the other's capacities, techniques and actions – hence this supplies another **major accelerant of evolution**
  - Eg gazelle v cheetah, virus v immune system, bacteria v antibiotic, pest v pesticide, computer virus v anti-virus software

Co-evolution – Cultural Arms Races

- We can see cultural **co-evolution** not just in military **arms races** – but in security
  - Safes and safebreakers
  - Coders and codebreakers
  - Arms and armour
  - Detection/concealment of weapons, explosives
  - Well-documented example – Rick Brown on car theft
- The changing social and technological **background** can favour first one side, then the other
  - e.g. radically better cutting tools, resistant materials emerge at various times
- Note that other kinds of co-evo can occur
  - **Symbiosis** – pooling of resources can occur between individual offenders or OCGs; and **partnerships** in crime prevention
  - **Competition** – e.g. between rival drug dealers or people smuggling groups

Co-evo – Running Arms Races by Boosting Good Side, Blocking Bad

- Encourage variety of preventive solutions
- Discourage variety of criminal solutions
- Design to performance standards/ generic principles
- Trap criminals in 1-off designs for success of their business model
- Study offender resources – current and future
- Block access to resources, knowledge of resources
- Exploit new technology for prevention
- Restrict new technology for crime
- Avoid rigidity – crime changes but your security can't
- Lock criminals into particular approaches
- Future proofing & Pipelines
- Make criminals focus effort on here & now solutions, limit their R&D

EVO – New Thinking in Evolution

- In last 2 decades, some evolutionary scientists have sought to pull together a range of ideas which do not supplant the ‘Modern Synthesis’ view of evolution but add to it – the ‘Extended Evolutionary Synthesis’ http://extendedevolutionarysynthesis.com/

- Several EES ideas are relevant to evolutionary approach to crime

- **Ecological inheritance** – where changes are stored/maintained in the **environment** rather than transmitted directly from one agent to another
  - Means that altered environment continues to exert these selection pressures over **generations**, boosting the evo trend
  - On the crime/security side, tools, weapons, buildings, paths, markets, financial or regulatory systems, lock crime/security patterns into place beyond the actions of individual offenders or OCGs
  - Each tool etc comes with expected/intended scripts for users
  - (The users may not respect these scripts in the case of repurposing for crime or security)

- **Niche construction** – organisms/agents don't just adapt to a fixed environment – there is a **feedback loop** in which the population of organisms changes the environment for itself and for successor generations
  - Eg grazing animals convert forest into grassland, to which they are already better-adapted
- But changing the environment may affect other species too – known as **Ecosystem Engineering**

Evo – New Thinking – Implications for Crime/Security

- At Evo level, cultural **niche construction/ eco inheritance** concepts can help us understand how offenders not only **adapt** to their environments of opportunity and security and change them on a one-off basis but actually make their environment **permanently more conducive to crime/terrorism**, whether deliberately or incidentally, physically, informationally or socially
  - Corruption
  - Insiders
  - Supportive or socialising community
  - Establishment of a **criminal market** or **value chain** for drugs or services

Evo – New Thinking – Implications for Crime/Security

- Likewise the 5Is concept of **climate setting** covers how **crime preventers** make the environment more conducive to **security**, eg in developing acceptance of preventive action, **mobilisation** and **partnerships**; less conducive to adversaries/ promoters
- **Ecosystem Engineering** means the environmental changes induced by offenders, promoters or preventers more broadly affect other crime/civil roles
  - E.g. we all have to do financial compliance procedures because of money launderers

Evo – New Thinking – Implications for Crime/Security

- Constructivist thinking also applies to the other levels
  - At **eco** level, individual offender may construct an **offensible space** conducive to their nefarious deeds – where unwary users led into place of tactical disadvantage – eg a physical ambush site, or cyber phishing trap
  - At **devo** level, individuals/groups may seek out who/what to learn from, and take charge of their own learning agenda – **constructive development**

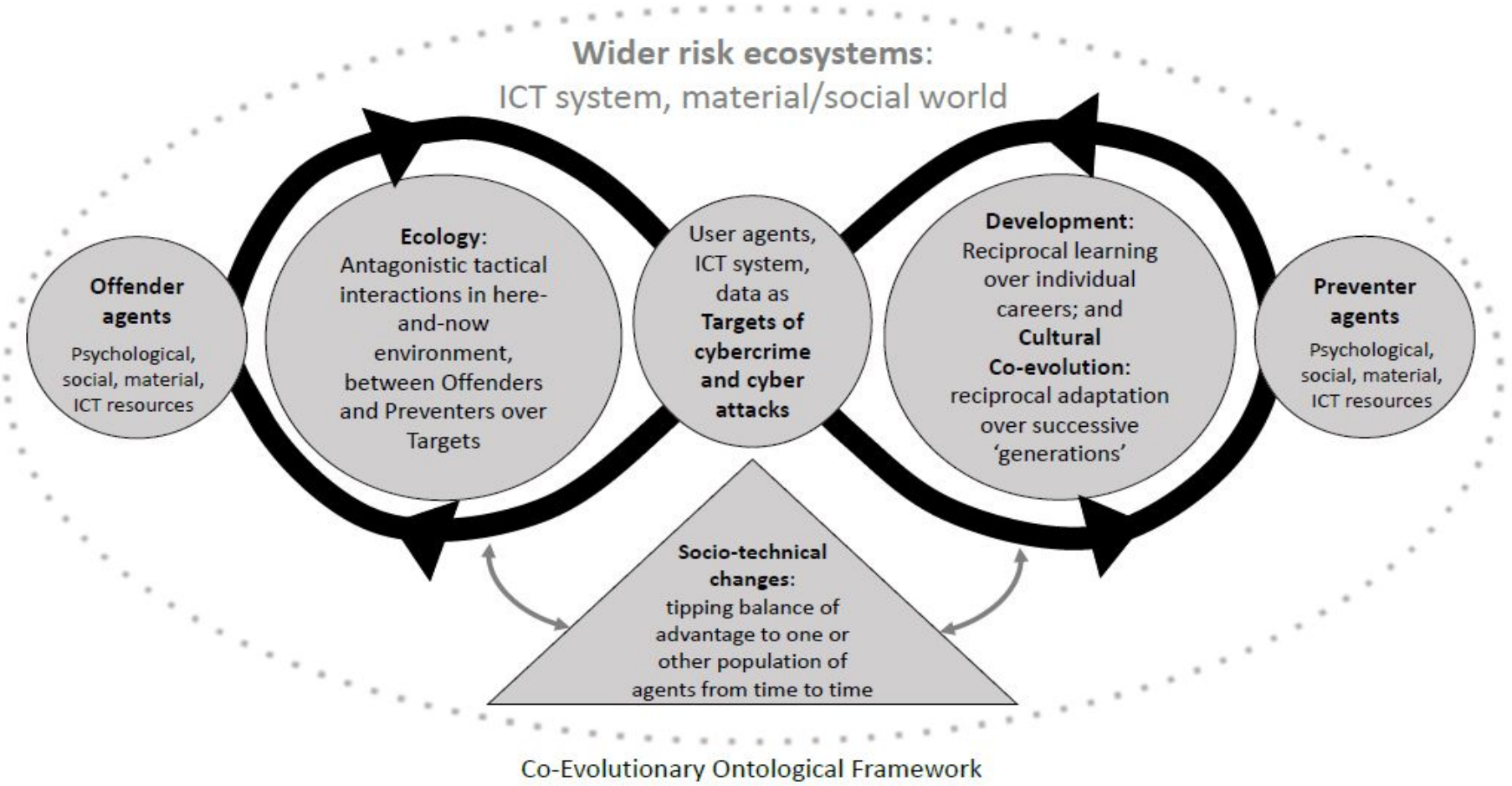
Interactive Nature of Agent-Environment relationship

- Conventional Crime Science/Situational Crime Prevention tend to view **opportunity** as simply ‘something in the environment out there’
- But **Situational Action Theory**, and the **Conjunction of Criminal Opportunity** framework, support a more interactive view
  - The concept of **affordance** – **perceived opportunity** in relation to what’s out there in **environment**, and what **resources** the offender/ preventer is able to bring to bear to **exploit** it and **cope** with the risks – converts a physical **Setting** into a **Situation**

Interactive Nature of Agent-Environment relationship

- Conventional crime science/criminology neglects many **feedback loops**
  - Operational feedback from failed/successful attempts at crime or security, individual/organisational learning, niche construction
- **Reciprocal causation** between changes in particular cultural traits and response of rest of cultural system
- Ecology of **perpetually disturbed ground** – plants evolve with rapid growth, short lifespan, lots of low-investment seeds (willowherb)
  - Some parallels with rapidly mobile/mutable cybercrimes that come and go as opportunities appear and are closed by continual social/ technological change, and the actions of security

A summary graphic from Project ACCEPT



Conclusions

- The 3 timeframes derived from biology offer distinctive ways of looking at crime, its causes and the interventions we can develop to prevent, mitigate or stop it
- Some of these build on conventional criminology/crime science, others are novel
- Some issues encountered are quite challenging, need further thinking through
- How far can we simplify our model of the ecosystem before it starts significantly losing the ability to guide understanding, decisions, planning and action?
- Alternatively, how far do we have to better articulate, broaden and integrate our existing crime science frameworks and render them dynamic?
- Project ACCEPT is endeavouring to take this process forward with development of an **ontology** of cybercrime, including human factors
- Feedback very welcome! In the meantime, some guidance…

Conclusions – for a Given Crime/Security Problem…

- Which **timeframe** is appropriate for understanding, tackling the problem – eco, devo, evo?
- Does a given crime reduction strategy need to address more than one?
- What are the **units, populations and societal levels** of interest?
- What are the most appropriate ways to view **generations**, particularly in the case of actions and things?
- How do all the agents and things fit together in a **crime ecosystem**? (And how does that fit more generally within broader societal systems?)
- How does **perturbing** one element of the system (e.g. offenders) affect all the other adaptive elements? Might there be counterintuitive outcomes, or even backfires?
- What factors **favour criminals** variously at eco, devo or evo levels? Or **favour security**? How can we boost the latter and bust the former?