

FLOW HIJACKED

The Borrowed Nervous System

Attachment, Co-Regulation and the Geometry of the Other

A long-form evidence-locked lecture on how other people can change regulation, prediction, transition cost and the reachable field of action.

Epistemic status. Empirical findings, supported interpretations, formal transfers and original Flow Hijacked hypotheses are separated throughout. *Borrowed Gain Geometry* is a proposed, falsifiable synthesis - not an established clinical mechanism.

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How to read this lecture

This lecture makes one controlled expansion of the Flow Hijacked framework: from an embodied, history-dependent individual system to an embodied, history-dependent, socially coupled system. Relationship is treated neither as decoration nor as destiny. The task is to ask which relational effects are already supported, which are plausible syntheses, and which remain new hypotheses.

EVIDENCE GRAMMAR

Empirical result - what a study directly reports.

Supported interpretation - a cross-study synthesis bounded by heterogeneity.

Flow Hijacked synthesis - integration through the project's dynamical lens.

Formal transfer - imported mathematics used only within its stated boundary.

New hypothesis - a falsifiable proposal not established by current evidence.

Open question - a discriminating test that remains unresolved.

The locked research system contains 360 included peer-reviewed sources after deduplication and relevance scoring, with a 166-source landmark spine, 32 major claim gates, 22 contradiction checks and a publication-level numerical lock. Numerical claims appear only where exact values were verified; elsewhere the text remains qualitative by design.

CLINICAL BOUNDARY

This is psychoeducation and a research synthesis. It does not diagnose a person, rate a relationship, prescribe contact or touch, alter medication, deny care, or replace individualized clinical judgment.

The central proposition

A person does not cease to be an individual system when another person enters the room. Yet the state-space in which that individual moves can become different. The same cue can acquire a different meaning, the same action can carry a different cost, and the same perturbation can produce a different recovery trajectory depending on who is present, how they are present and what the history between them predicts.

The cautious claim is already strong: relational context can alter stress, appraisal, behavior, pain, attention and regulation. The stronger Flow Hijacked question is whether some relational contexts change effective gain and reachability rather than merely adding an input. That stronger claim is reserved for Part XV, where it must compete against simpler models.

Core sentence

Relational context can change movement conditions; identify what changed.

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PART 01**The Other Enters the Equation**

The central move of this lecture is deceptively simple: another person is not merely part of the scenery around a nervous system. A relationship can alter what a cue means, what a threat costs, which actions feel reachable, and how quickly a disturbed state can return. The scientific challenge is to say this without turning metaphor into mechanism. We therefore begin with the strongest, least controversial claim - social context can change human regulation - and only later ask whether it sometimes changes the geometry of response itself. **Theoretical background**

The individual-as-sealed-unit model is a deliberate simplification. It is indispensable for many experiments because it lets researchers isolate inputs and outputs, but it can become misleading when carried into a theory of human regulation. Human nervous systems develop in environments that are already populated by other nervous systems. From infancy onward, arousal, attention, threat appraisal and action are repeatedly shaped inside episodes of approach, withdrawal, signalling, waiting and repair. Relational regulation theory and multisystem accounts of resilience therefore treat regulation as distributed across levels rather than confined to one organ or one person.

A second theoretical strand comes from Social Baseline Theory and adjacent work on social buffering. The central idea is not that company is inherently calming. It is that predictable access to familiar others can alter expected effort, vigilance and resource demand under some conditions. That distinction matters. A supportive other may change the meaning of a task, the cost assigned to an action, the expected consequences of failure or the amount of self-monitoring required. Conversely, an unreliable or threatening other can increase those costs.

Flow Hijacked takes these traditions as a starting point but imposes a stricter systems question. When behavior changes in the presence of another person, what changed mathematically? Was there only an additional input? Did the operating point shift? Did observation or noise change? Did the effective coupling or local gain change? The lecture will preserve these alternatives instead of collapsing them into the vague claim that relationships 'regulate' people. **Theoretical anchors:** S013-S016; S102-S111; S139-S143

What this part must establish

- 01** Alone Is Not the Default
- 02** Presence Can Change Cost, Not Only Comfort
- 03** Buffering Is Conditional
- 04** From Input to Geometry

The human problem first; the mathematics only where it buys precision.

01. Alone Is Not the Default

Much of psychology is written as if the person were a sealed unit: stimulus enters, computation occurs, response leaves. That abstraction is useful, but biologically incomplete. Human development starts inside repeated exchanges with other people. Regulation of arousal, attention, distress and action is learned in a field that already contains voices, faces, touch, absence, unpredictability and repair. Adult autonomy does not erase this history; it sits on top of it.

This does not mean that every difficulty is relational, or that another person is required for every act of regulation. It means the baseline model should permit social variables to enter the dynamics rather than treating them as decorative context. A trusted partner, a threatening audience and an indifferent stranger can produce different trajectories from the same nominal cue.

Flow Hijacked therefore begins with a coupled formulation: the person remains an agent with an internal state, but the vector field is allowed to depend on relational context. The gain may change, the operating point may shift, or only the input may differ. Those possibilities must be separated experimentally rather than collapsed into one story.

Evidence boundary

Supported interpretation. Relational modulation is well supported; an operator change is not assumed.

Evidence anchors: C01, C23; S008-S012, S102-S111

02. Presence Can Change Cost, Not Only Comfort

Support is often described in emotional language - comfort, reassurance, warmth. Those words matter, but they can hide a more technical possibility. Under some conditions, familiar social proximity changes perceived effort, vigilance and threat. The person may not simply feel better; the same action may require less regulatory work.

Social Baseline Theory and adjacent experimental work motivate this control-cost interpretation, but the effect is not universal. A familiar other can be irrelevant, distracting, demanding or unsafe. Mere co-presence is often insufficient. Relationship quality, predictability, the channel of support and the task all matter.

For Flow Hijacked, this suggests a disciplined question: does another person alter the effective cost of moving from one state to another? The phrase “borrowed nervous system” should not imply that one brain literally runs another. It names a situation in which resources, prediction and regulation are partly distributed across a relationship, making some transitions easier and others harder.

Evidence boundary

Qualitative synthesis only. No universal percentage reduction in threat or effort is authorized.

Evidence anchors: C23, C29; S102-S111, S139-S143

03. Buffering Is Conditional

“Social support is protective” is true only at a level of abstraction that can become misleading. Across studies, support is associated with better adjustment on average, yet the category contains very different events: touch, advice, presence, practical help, validation, eye contact, silence, shared action and the knowledge that someone is available. The nervous system does not receive these as interchangeable doses of “support.”

The same intervention can also fail. Advice can increase shame. Touch can be unwanted. A visit can overload someone who needs distance. A person whose history predicts criticism may interpret reassurance as surveillance or disbelief. This is why the coupling term in a useful model must depend on relationship, channel, state and time.

The practical consequence is important. Co-regulation is not something one person simply administers to another. It is a negotiated fit between a state, a relationship and a form of contact. The geometry of the other begins with specificity.

Evidence boundary

Strong correction to monotonic support narratives. Who, how, when and through which channel must remain visible.

Evidence anchors: C01, C29; X09, X19; S012, S029, S139-S143

04. From Input to Geometry

A supportive voice clearly adds information. The harder question is whether relationship can do more than add input. Suppose the same words, spoken by different people, produce different sensitivity to threat, different recovery after perturbation or different access to speech and choice. Several explanations remain possible: the starting state changed, expectation changed, noise fell, attention shifted, or the local dynamics themselves changed.

This distinction matters because Flow Hijacked is interested in transitions. If relationship merely supplies an input, then the internal operator can remain fixed. If relationship alters effective gain, coupling or local stability, the reachable state-space may change. Borrowed Gain Geometry is the name reserved for that stronger possibility.

The lecture will not assume the strong hypothesis simply because it is elegant. We will build toward it through developmental, autonomic, synchrony, predictive and clinical evidence, then ask what data could distinguish an operator-change account from simpler alternatives.

Evidence boundary

New Flow Hijacked hypothesis. No relational operator, resolvent norm or gain value has been empirically estimated.

Evidence anchors: C12; FH Formal Bridge; BGG M0-M4

PART 02

Attachment as Regulatory History

Attachment becomes most useful here when it stops being a personality label. It can be treated as a family of learned expectations about availability, threat, proximity, self-worth and what happens after distress is expressed. Those expectations are probabilistic, context-sensitive and revisable. They are candidates for slow variables in a multiscale model, not permanent identities. **Theoretical background**

Attachment theory began as an account of how organisms organize proximity to caregivers under threat, but its modern relevance is broader than a catalogue of childhood categories. In developmental and adult research, attachment is measured through partially overlapping traditions: observed patterns, interviews, representations and dimensional self-report measures. Those methods do not identify an immutable essence. They describe regularities in expectation, attention, memory and regulation that are shaped by experience and expressed probabilistically.

A useful systems interpretation is to treat attachment-related expectations as history-dependent parameters. Repeated relational sequences teach a nervous system what tends to happen after distress is expressed, whether proximity is available, whether need becomes costly, and how quickly conflict is repaired. In predictive terms, these experiences can alter priors and precision: the same delayed reply, facial expression or disagreement may carry very different inferred meanings depending on learned relational history.

This framing also explains why attachment can be stable without being destiny. Slow variables are slow because they integrate experience across time, not because they cannot change. New relational evidence can coexist with older expectations for long periods, and state dependence matters: an old pattern may reappear under sleep loss, threat or grief even after substantial growth. The scientific task is therefore to study updating, generalization and context sensitivity rather than to sort people into fixed boxes. **Theoretical anchors:** S001-S007; S090-S093

What this part must establish

- 01** Attachment Is Not a Personality Type
- 02** Priors Written Through Repetition
- 03** Security, Anxiety and Avoidance Are Tendencies
- 04** Attachment Can Change Without Being Erased

The human problem first; the mathematics only where it buys precision.

05. Attachment Is Not a Personality Type

Popular attachment language often hardens continuous tendencies into four fixed kinds of people. The research literature is less theatrical. Measures differ, categories and dimensions are not interchangeable, and associations with mental health are probabilistic rather than deterministic. In a large adult meta-analysis, attachment anxiety and avoidance were associated with poorer mental-health outcomes, but the numbers describe population-level relationships, not a destiny written into an individual.

The useful question is therefore not “What type am I?” but “What does my system expect when closeness, need, conflict or separation appears?” Those expectations can shape attention, memory, appraisal and regulation without becoming an essence.

For Flow Hijacked, attachment fits naturally among slow parameters and priors. It can bias the vector field without fixing every trajectory. A person may show different behavior across relationships because the relational context is part of the state, not noise around it.

Locked quantitative note

Adult attachment meta-analysis: 224 studies, 245 samples, $N=79,722$; anxiety with negative mental health $r=.42$, avoidance $r=.28$. These are associations, not deterministic effects.

Evidence boundary

Do not infer an individual diagnosis, fixed type or causal percentage from population correlations.

Evidence anchors: C02, C19; NL06, NL07, NL08

06. Priors Written Through Repetition

A child does not need a theory of attachment in order to learn one. Repeated sequences are enough: distress appears; someone responds, ignores, escalates, soothes, disappears, repairs. Across thousands of ordinary episodes, the nervous system learns not only what others do but how costly it is to signal need and how quickly a disturbed

state tends to settle.

This is where attachment meets predictive processing. A prior is not a conscious belief. It is a weighted expectation that changes interpretation before deliberation is complete. A neutral pause may be read as abandonment in one history and as ordinary space in another.

The Flow Hijacked move is to place these expectations on slower timescales. Fast episodes of arousal occur inside a slower relational model. Repetition can reinforce the model, but sufficiently informative experiences can also update it. The aim is not to declare one developmental pathway universal; it is to represent history without turning history into destiny.

Evidence boundary

Predictive language is a synthesis across literatures; it is not a single established attachment mechanism.

Evidence anchors: C02, C11, C31; S003-S007, S050-S057

07. Security, Anxiety and Avoidance Are Tendencies

Attachment dimensions can be clinically meaningful because they change probabilities. Higher anxiety may increase vigilance to rejection and the urgency of proximity seeking. Higher avoidance may increase deactivation, distance and reluctance to depend on others. Yet the same person can behave differently with a spouse, a therapist, a parent or a colleague.

That variability is not a nuisance to be averaged away. It is evidence that relational regulation is conditional. Working-alliance meta-analysis finds only small average associations between attachment insecurity and alliance, which is exactly what a dynamical account should expect: history matters, but present interaction can still move the trajectory.

The practical reading is humane. A pattern is neither an excuse nor a verdict. It is a set of learned tendencies that may become more visible under load. The relevant clinical question is what happens to those tendencies when the relationship is predictable enough to permit another response.

Locked quantitative note

Working-alliance associations are small on average: attachment anxiety $r=-.09$ and avoidance $r=-.13$ ($k=33$ each).

Evidence boundary

Small group-level associations do not determine the alliance or behavior of a

particular person.

Evidence anchors: C02, C19; NL19

08. Attachment Can Change Without Being Erased

Change is sometimes imagined as deleting the old pattern. A more plausible picture is layered learning. Earlier expectations may remain available, especially under fatigue, threat or loss, while new relational models become increasingly accessible and trusted. This helps explain why growth can be real even when an old reaction occasionally reappears.

A slow variable need not be immutable. In dynamical systems, slow means that change accumulates across repeated episodes rather than that change is impossible. The central question becomes whether new experiences alter prediction, recovery, flexibility and the cost of asking for help.

This also protects the concept of autonomy. The goal is not permanent dependence on a perfectly regulating other. Healthy relational learning should enlarge the person's repertoire: more ways to settle, speak, leave, return, negotiate and use support selectively. The other is valuable when the field becomes wider after the encounter, not only quieter during it.

Evidence boundary

The lecture treats slow relational updating as a Flow Hijacked synthesis; direct person-level parameter identification remains incomplete.

Evidence anchors: C11, C19, C22; Fast-slow bridge

PART 03

The Body Learns Another Person

Relationship is not stored only in narrative memory. It is carried in timing, posture, vigilance, voice, interoception and the expectation of what another body will do next. Co-regulation is therefore embodied, but embodiment must not be romanticized: touch can help, overwhelm or violate; eye contact can invite or threaten. Channel and consent belong inside the science. **Theoretical background**

Developmental regulation is embodied before it is verbal. Early interaction depends on temporal coordination: approach and retreat, vocal rhythm, facial expression, posture, gaze and touch. These channels are not interchangeable, and their meaning is inseparable from timing and relationship history. A touch that regulates in one context may intrude in another; a pause that creates space in one relationship may signal

abandonment in another. This is why a serious account of co-regulation must retain sensory channel, consent and context.

The body also learns through contingency. When signals are followed by reliable responses, the organism can learn that distress is survivable and communication has consequences. When responses are chaotic, frightening or absent, the same outward behavior may acquire different regulatory functions. Developmental neuroscience adds another layer: stress systems, attentional priorities and plasticity are shaped across sensitive periods, but the evidence does not justify a single deterministic pathway from early caregiving to adult neural state.

For adults, the important continuity is functional rather than infantile. Voice, pacing, facial expression, predictable contact and physical proximity can still change appraisal and action, especially under load. Yet mature co-regulation should not be defined as one person taking over another person's nervous system. Its healthier form preserves consent and expands agency. The criterion is not how completely one person can calm another, but whether interaction leaves the person with a broader capacity to choose, disengage, return and regulate across contexts. **Theoretical anchors:** S003-S007;

S027; S139-S143

What this part must establish

- 01** Development Begins in Dyads
- 02** Voice, Gaze, Touch and Timing
- 03** Mere Presence Is Often Not Enough
- 04** Borrowing Regulation Without Surrendering Agency

The human problem first; the mathematics only where it buys precision.

09. Development Begins in Dyads

Before a child can name an emotion, regulation already has timing. Someone approaches, waits, amplifies, softens, turns away and returns. These exchanges are not a miniature psychotherapy session; they are the ordinary material from which expectations about distress and recovery are built.

Developmental evidence does not justify a single deterministic script. Caregiving is heterogeneous, children differ, sensitive periods are not identical for every function, and broader ecology matters. Still, the general point is robust: regulatory development is relational from the beginning.

Flow Hijacked uses this to reject a false opposition between “self-regulation” and “co-regulation.” Self-regulation is partly constructed through prior co-regulation. What later looks internal may have been trained in repeated interpersonal loops. The mature system is not less relational because it can stand alone; it has learned when and how to distribute regulation without losing agency.

Evidence boundary

Developmental association does not permit blaming caregivers or deriving a fixed adult outcome from early history.

Evidence anchors: S003-S007, S090-S093; C19

10. Voice, Gaze, Touch and Timing

A relationship reaches the nervous system through channels. Prosody can signal urgency or safety. Gaze can coordinate attention or intensify scrutiny. Touch can change pain and stress responses under some conditions. Timing determines whether an intervention lands before, during or after a peak of arousal.

It is tempting to collapse these channels into one variable called “connection.” That loses information. Different sensory and social channels recruit different pathways and can carry opposite meaning depending on history and context.

A more useful model keeps a vector of coupling channels. The same partner may regulate effectively through voice and poorly through touch. A message may help when planned and intrude when unexpected. Co-regulation therefore has a geometry not only of people, but of routes through which people reach one another.

Evidence boundary

No generic magnitude for touch or verbal support is authorized; effects are relationship-, task- and outcome-dependent.

Evidence anchors: C29; S139-S143, S027

11. Mere Presence Is Often Not Enough

The phrase “you do not have to do this alone” can be clinically powerful, but science requires a second sentence: being with someone is not automatically regulating. Meta-analytic and experimental work on pain and stress shows that mere presence can be weak, null or dependent on relationship and appraisal.

This distinction prevents a subtle moral error. If support fails, the person has not necessarily rejected help, and the supporter has not necessarily failed to care. The channel may simply not match the state. An overwhelmed person may need quiet co-presence rather than questions; another may need explicit reassurance; another may need distance and a reliable invitation to reconnect later.

Flow Hijacked therefore models support as context-sensitive coupling, not a constant positive force. A good relational intervention changes with the state rather than demanding that the state conform to the intervention.

Evidence boundary

Support is a fit problem, not a moral scalar. Presence alone should not be prescribed as a universal buffer.

Evidence anchors: X19, C29; S139-S143

12. Borrowing Regulation Without Surrendering Agency

The phrase “borrowed nervous system” can sound as if regulation belongs to the stronger person and is loaned to the weaker one. That is not the intended model. Regulation is co-produced. The supported person still perceives, chooses, resists, accepts, leaves and returns. The other person changes conditions; they do not own the trajectory.

A healthy form of borrowing should therefore be judged by what remains after the interaction. Does the person have more access to speech, choice, sleep, action or perspective? Can they later reproduce some of the transition without the same partner? Does the relationship widen the social field or concentrate all regulation in one bond?

The measure of co-regulation is not permanent calm. It is increased returnability with preserved consent. The strongest relationship is not the one that becomes indispensable, but the one that helps more of the person’s own capacities become reachable.

Evidence boundary

Relational help must increase agency or preserve it; the framework never justifies coercion, forced contact or surveillance.

Evidence anchors: C11, C23, C29; clinical boundary

PART 04

Social Buffering and Autonomic Regulation

Stress physiology is social, but it is not simple. Another person can change appraisal, vigilance, pain and autonomic response, while the same social field can also intensify threat. This part keeps the physiology multivariate. Heart-rate variability is useful, but it is not a meter of felt safety; the autonomic nervous system cannot be reduced to one ratio or one popular diagram. **Theoretical background**

Stress physiology is often described as though it were triggered by objective events alone. In reality, endocrine and autonomic responses depend heavily on appraisal, predictability, controllability and learned meaning. Social context can enter each of these variables. A trusted partner may reduce uncertainty or change the inferred

consequences of a threat; a critical observer may amplify vigilance even when the external task is identical. Social buffering therefore belongs inside a model of stress computation rather than outside it as an afterthought.

The autonomic nervous system is especially vulnerable to oversimplification. Heart-rate variability is valuable because it provides a non-invasive window onto aspects of cardiac autonomic regulation, but it is multiply determined. Respiration, posture, age, fitness, medication, recording duration and analytic choices matter. Low-frequency power is not a simple readout of sympathetic activity, the LF/HF ratio is not a validated dial of 'sympathovagal balance', and no single HRV value can certify that a person feels safe.

This measurement discipline changes the theoretical story. Social support should be modeled as one factor that can alter appraisal, action cost and physiological recovery, not as a universal switch that turns the body from danger to safety. Polyvagal Theory can be discussed as an influential clinical framework, but disputed neuroanatomical and evolutionary claims should not carry the mechanistic backbone. A stronger account uses broader autonomic physiology and keeps the unresolved theory-specific claims visible. **Theoretical anchors:** S008-S012; S079-S085; S102-S111

What this part must establish

- 01** Stress Systems Are Socially Modulated
- 02** HRV Is Useful - and Easy to Overread
- 03** Social Baseline as Control Cost
- 04** When Support Misfires

The human problem first; the mathematics only where it buys precision.

13. Stress Systems Are Socially Modulated

A stress response is not generated by the event alone. It depends on appraisal, controllability, prediction, prior learning and the social field in which the event occurs. Human and animal studies show that familiar others can alter endocrine, autonomic, behavioral and neural responses, but the effect varies across relationship, development and task.

The important scientific move is to resist a single "co-regulation pathway." Social buffering can involve threat appraisal, attention, learned safety, sensory input, reward, pain modulation and neuromodulation. Different experiments capture different slices of that system.

For Flow Hijacked, stress is therefore best represented as a family of coupled state variables. A relationship may reduce the amplitude of one component while leaving another unchanged. It may shorten recovery without changing peak response, or change behavior without producing a large autonomic shift. A multivariate model is less catchy than a one-number story, but more faithful to the nervous system.

Evidence boundary

No single physiological pathway or effect size represents social buffering across contexts.

Evidence anchors: C01, C23, C29; S008-S016, S102-S111

14. HRV Is Useful - and Easy to Overread

Heart-rate variability has earned a strange double life. In physiology it is a family of measures derived from beat-to-beat variation under specific recording and analytic conditions. In popular mental-health discourse it is often treated as a direct readout of “nervous-system safety.” Those are not the same claim.

Respiration, posture, age, fitness, medication, recording length and analytic choices all matter. Modern guidelines explicitly caution against interpreting HRV as a specific marker of sympathetic outflow or simple sympathovagal balance. The familiar LF/HF shortcut is especially problematic.

This does not make HRV useless. It makes it one measurement among several. Flow Hijacked treats cardiac autonomic indices as observables, not as the latent state itself. A person can feel unsafe with one HRV pattern and safe with another; a relationship can matter even when a chosen cardiac measure changes little. Measurement discipline is part of compassion because it prevents physiology from becoming another verdict about the person.

Evidence boundary

No HRV threshold is a safety threshold. LF/HF must not be described as direct sympathovagal balance.

Evidence anchors: C16; X04, X14, X15; NL16; S079-S082

15. Social Baseline as Control Cost

One way to formalize the value of a trusted other is not to say that the person adds calm, but that they alter expected cost. If the environment is shared with someone reliable, vigilance, planning and defensive readiness may not need to be carried by one organism alone. Some experiments are consistent with reduced effort or threat under familiar social proximity.

The word “cost” should remain carefully bounded. It can refer to expected effort, task demand or control burden; it does not imply that every paradigm has measured literal metabolic expenditure. Nor does the theory predict that any company is better than solitude.

In Flow Hijacked, control cost becomes a bridge to reachability. A transition from

silence to speech or from panic to deliberate action may be easier in one relational context than another. That is a testable difference in behavior and dynamics, even before we claim a change in the internal operator.

Evidence boundary

Control-cost language is a supported interpretation, not a claim of universally measured metabolic savings.

Evidence anchors: C23; S102-S111; Formal Bridge: social baseline/control cost

16. When Support Misfires

A nervous system does not evaluate support by the helper's intention. It evaluates what actually arrives. A reassuring phrase can sound minimizing. Repeated checking can feel like surveillance. Advice can add a performance demand to someone already overloaded. "Calm down" can become evidence that the current state is unacceptable. This is not an argument against support. It is an argument for feedback. Effective co-regulation requires sensitivity to mismatch and permission to revise the channel. The response of the supported person is data, not ingratitude.

In a dynamical frame, misattuned support can push in the wrong direction or increase gain around threat. The same nominally positive input may have different effects because the relational history changes its meaning. A mature model therefore includes sign changes: coupling can stabilize, destabilize or do almost nothing. This is one reason the lecture refuses the equation social contact = safety.

Evidence boundary

Support quality, consent and appraisal matter; no model should convert "support" into a fixed positive coefficient.

Evidence anchors: X09, X19; C23, C29

PART 05

Chemistry Without Myth

Social life is chemically embodied, but no molecule owns love, trust or belonging. Oxytocin, dopamine, endogenous opioids and other neuromodulators influence salience, learning, reward, pain, motivation and plasticity in context-dependent ways. The goal of this part is not to replace one simplistic story with four. It is to show why the same social cue can produce different dynamics in different biological states. **Theoretical background**

The neurochemistry of social life is tempting because it invites simple stories. Oxytocin becomes love, dopamine becomes reward, endogenous opioids become bond-

ing. Those labels are memorable but biologically misleading. Neuromodulators act through receptor distributions, circuit state, dose, timing and context. The same molecule can alter salience, learning, approach, stress or plasticity differently across brain regions and tasks. Peripheral assays add another complication because blood or saliva concentrations are not a transparent readout of synaptic signaling in specific neural circuits.

A systems view is more useful. Oxytocin, dopamine, opioids, noradrenaline and serotonin can be treated as interacting control parameters that reshape response properties rather than encode one emotion each. Social affiliation can recruit reward and opioid systems, yet pharmacological blockade studies show that no single axis is the substrate of human connection. The effect of μ -opioid antagonism on social connection is modest on average, and social reward studies vary enormously in intimacy, immediacy, interaction and phase.

The theoretical payoff is precision. Instead of asking which 'chemical' produces trust, the lecture asks how neuromodulatory state changes gain, learning rate, salience and plasticity for a particular person in a particular context. That formulation connects molecular evidence to Flow Hijacked without pretending that a transmitter is a psychological state. It also explains why the same social cue can be inviting in one state and aversive in another. **Theoretical anchors:** S008; S029-S038; S086-S089; S131-S137

What this part must establish

- 01** Oxytocin Is Not the Trust Hormone
- 02** Opioids Modulate Connection; They Do Not Define It
- 03** Social Reward Is Not One Reward
- 04** Neuromodulators as State-Dependent Parameters

The human problem first; the mathematics only where it buys precision.

17. Oxytocin Is Not the Trust Hormone

Oxytocin is probably the most overcompressed molecule in popular social neuroscience. It has been called a love hormone, a trust hormone and a bonding chemical, as if one concentration mapped cleanly onto one human meaning. The human literature does not support that simplicity.

A large systematic review and meta-analysis of endogenous oxytocin found heterogeneous and generally small effects across designs. Assay method, context, sex, developmental stage and the kind of social interaction matter. Some causal designs do not show the expected universal rise after social interaction.

The stronger interpretation is more interesting than the myth. Oxytocin participates in context-sensitive social and stress processes. It may alter salience, learning or approach under some conditions without guaranteeing prosocial behavior. Flow Hijacked therefore treats it as one control parameter in a higher-dimensional system, never as a scalar measure of bond quality.

Locked quantitative note

63 studies were reviewed qualitatively; 51 were pooled ($n=3,741$). Locked effects are small/heterogeneous: causal pre-post $g=.079$; social vs no-social $g=.256$.

Evidence boundary

Do not translate these effects into “trust” or claim a universal prosocial response.

Evidence anchors: C05, C18; X02, X13; NL13

18. Opioids Modulate Connection; They Do Not Define It

Endogenous opioid systems contribute to social reward, pain and affiliative experience, which makes them attractive candidates for a biological substrate of connection. Pharmacological studies in humans support a role, but not the stronger claim that social connection requires intact mu-opioid signaling.

A preregistered meta-analysis of antagonist studies found a modest average reduction in social connectedness under naltrexone. Importantly, connectedness remained robust under blockade, and the literature showed possible small-study bias.

For Flow Hijacked, this is a useful lesson in causal humility. A system can be modulatory without being necessary or sufficient. Opioid tone may change the gain of social reward or pain without determining whether a relationship exists. The nervous system is redundant, context-sensitive and multi-parameter; belonging is not a receptor state.

Locked quantitative note

Naltrexone meta-analysis: 17 outcomes, $N=455$, Hedges $g=-.20$, 95% CI $[-.32, -.07]$, $I^2=23\%$; possible small-study bias.

Evidence boundary

Mu-opioid signaling is a modulator, not a necessary substrate of human connection.

Evidence anchors: C06, C27; X20; NL14

19. Social Reward Is Not One Reward

A smile from a stranger, a message from a child, praise from a supervisor, sexual intimacy, cooperative play and public approval are all called “social reward.” They do not form a single stimulus class in any simple neural sense. Intimacy, sensory richness, immediacy, reciprocity and reward phase change what is being measured.

A systematic review mapping hundreds of studies makes this heterogeneity explicit. It also warns against treating dopamine as the chemical meaning of “liking people.” Dopamine participates in motivation, prediction, learning and action selection across social and nonsocial domains.

For the Borrowed Nervous System, this matters because relational gain depends on what the social event actually is. The coupling term should change with intimacy and interaction, not merely with “social versus nonsocial.” A live trusted exchange, a recorded voice and an abstract symbol of support may share meaning while recruiting different dynamics.

Locked quantitative note

A preregistered review mapped 384 studies and 42,118 participants/subjects; no single pooled “social reward effect” exists.

Evidence boundary

No numerical dopamine effect is authorized in the lecture’s numerical lock.

Evidence anchors: C06, C28; NL15; S132-S137

20. Neuromodulators as State-Dependent Parameters

The more useful systems view is not “oxytocin equals trust” or “dopamine equals reward.” Neuromodulators change the response properties of circuits. They can alter salience, plasticity, exploration, pain, learning rates and the relative influence of competing inputs. Their meaning therefore depends on receptor distribution, region, baseline state, timing and context.

This gives Flow Hijacked a disciplined bridge. In a dynamical model, neuromodulatory variables can enter as parameters that reshape gain and transition probabilities over different timescales. That does not imply that we can read a psychological state directly from a transmitter level.

Relational context and neuromodulation also interact. A cue from a trusted person may arrive in a different biological state than the same cue during withdrawal, sleep deprivation or threat. The “same relationship” is therefore not the same dynamical experiment on every day.

Evidence boundary

“Control parameter” is a systems interpretation bounded by biology, not a claim that transmitter levels can be used as clinical knobs.

Evidence anchors: C05, C06, C18, C27, C28; Formal Bridge: neuromodulatory control parameters

PART 06

Synchrony Is Not Harmony

Two people can become temporally coordinated in movement, physiology and neural activity. That observation is real, measurable and scientifically exciting. It is also one of the easiest findings to romanticize. Synchrony can reflect cooperation, shared stimulus, common stress, mimicry, task structure or mutual dysregulation. The question is not whether signals line up, but what the alignment means in that system. **Theoretical background**

Synchrony is a family of measurements, not a single biological substance. Researchers may quantify temporal correspondence between movement, speech rhythm, heart rate, electrodermal activity, EEG, fNIRS or other signals. Those signals operate at different timescales and are generated by different mechanisms. Two people can therefore be highly synchronized in one modality and weakly coupled - or even oppositely related - in another.

This creates an identification problem. Apparent synchrony can arise because two people truly influence one another, but it can also arise from shared sensory input, task timing, common movement, respiration or analytic choices. Hyperscanning studies have made social neuroscience more naturalistic, yet the interpretation of inter-brain coupling requires null models, motion controls, temporal directionality and careful separation of common input from mutual influence. Correlation alone does not establish information transfer from one brain to another.

The most important correction is functional. Synchrony is not intrinsically healthy. A distressed dyad can synchronize into vigilance, conflict or rumination; a flexible relationship may sometimes require decoupling so that one person can remain stable while the other is dysregulated. Meta-analytic findings in psychotherapy and autonomic coupling support this non-monotonic view. Flow Hijacked therefore models a coupling matrix with modality, sign, lag and context rather than a scalar 'synchrony score'. **Theoretical anchors:** S017-S028; S072-S073; S094-S098

What this part must establish

- 01** What Synchrony Actually Measures
- 02** Modalities Can Disagree
- 03** More Synchrony Is Not Better
- 04** Common Input Is Not Mind-to-Mind Transfer

The human problem first; the mathematics only where it buys precision.

21. What Synchrony Actually Measures

Synchrony is not one phenomenon. Researchers compute correspondence across movement, facial behavior, speech, cardiac signals, electrodermal activity, EEG, fNIRS and other measures, using different windows and statistics. A finding in one modality cannot be silently promoted into a claim about “the relationship.”

Meta-analytic evidence shows cross-level associations: neural and behavioral synchrony covary on average, as do physiological and behavioral synchrony, but the magnitudes differ. That supports the existence of coordinated social dynamics while also rejecting a single latent synchrony score.

Flow Hijacked therefore treats synchrony as a matrix of couplings. Some entries may strengthen while others weaken. The pattern, lag and direction may be more informative than magnitude alone. This makes the science less intuitive, but it prevents a seductive error: confusing visible temporal alignment with relational health.

Locked quantitative note

Neural-behavioral synchrony: 37 samples, $N=1,342$, $r=.32$ [95% CI .23,.41].
Physiological-behavioral: 13 samples, $N=369$, $r=.18$ [.06,.30].

Evidence boundary

Do not collapse modality-specific estimates into one universal synchrony coefficient.

Evidence anchors: C03, C20; NL10; S017-S028, S094-S098

22. Modalities Can Disagree

Imagine a couple speaking calmly while both bodies remain highly activated, or two people showing similar heart-rate dynamics while their behavior diverges. These are not contradictions. Different measurement channels track different processes, on different timescales and with different confounds.

Autonomic synchrony is a particularly instructive example. Branch-specific effects can differ in sign, and overall relationship effects are small and heterogeneous. In psychotherapy, nonverbal synchrony also shows modality-specific results rather than a uniform association with alliance or outcome.

The implication is methodological and conceptual. A coupled system can be coordinated in one subspace and decoupled in another. Flow Hijacked therefore resists the temptation to summarize an interaction with one “togetherness” variable. What matters is the configuration of coupling across channels and the function of that configuration.

Locked quantitative note

Autonomic relationship effect $ES=.09$ ($p>.10$; $I^2=76\%$). Psychotherapy nonverbal synchrony overall $r=.03$ ($p=.644$), with modality-specific opposite-sign effects.

Evidence boundary

Heterogeneity is not a nuisance here; it is part of the phenomenon.

Evidence anchors: C04, C20; NL11, NL12

23. More Synchrony Is Not Better

The intuitive story is attractive: healthy people connect, therefore their bodies and brains synchronize more. But systems can synchronize in distress as well. Two people can escalate one another, lock into reciprocal vigilance or coordinate around avoidance. High alignment can be adaptive in one task and maladaptive in another.

Meta-analytic psychotherapy data are particularly useful because they break the romance directly. Overall nonverbal synchrony is not a strong monotonic predictor of alliance or outcome. Some modalities show positive relations, others negative or null ones.

A better target is flexible coordination. Healthy co-regulation may require periods of matching and periods of differentiation: one person remains stable while the other is distressed; one slows while the other accelerates; coordination appears when useful and dissolves when autonomy is needed. The aim is not maximal synchrony but functional coupling.

Evidence boundary

“More is better” is explicitly rejected. Function must be established independently of synchrony magnitude.

Evidence anchors: C04, C24; X01, X12; NL11, NL12

24. Common Input Is Not Mind-to-Mind Transfer

When two brains show correlated activity during conversation, the finding is intriguing. It does not by itself demonstrate direct information transfer between brains. Both people see the same room, hear the same words, move in related ways and follow the same task structure. Those common inputs can create coupling.

Good hyperscanning research increasingly addresses movement, shared stimulus, surrogate data, lag structure and directionality. Even then, statistical directionality is not automatically intervention-level causality.

Flow Hijacked therefore asks for stronger evidence before using inter-brain coupling

as a mechanism. The relevant question is whether one person's state contributes predictive information about the other's future trajectory beyond common input and autocorrelation, and whether perturbing the relationship changes that dependency. Synchrony is a starting measurement, not the final causal story.

Evidence boundary

Hyperscanning can reveal coordinated signals. It does not, by correlation alone, prove direct brain-to-brain transfer.

Evidence anchors: C03; X05; S018, S022, S025, S026

PART 07

Predicting Each Other

A social encounter is not merely two streams of sensation. Each person is estimating what the other means, what they will do next, and how reliable their signals are. Predictive-processing and active-inference frameworks offer a formal vocabulary for this mutual inference. They are useful precisely when kept honest: powerful as generative frameworks, still incomplete as uniquely confirmed mechanisms of social interaction. **Theoretical background**

Social interaction is partly an inference problem. Other people are never observed directly as intentions; they are inferred from behavior, timing, context and history. A delayed answer can mean distraction, rejection, caution or nothing important at all. The nervous system must combine ambiguous evidence with prior expectations, and it must decide how much weight to give each source. Predictive-processing language is useful here because it separates prediction from precision: an expectation matters differently depending on how confident the system is in that expectation and in the incoming signal.

Trust can therefore be framed, cautiously, as a change in the weighting and updating of social evidence. Repeated reliable interaction may make benign interpretations more available or reduce the amount of evidence required before safety is inferred. Repeated betrayal can do the opposite. This does not mean that every attachment or therapy process is literally implemented by one predictive-coding algorithm; several computational frameworks can reproduce similar behavior.

Active inference extends the vocabulary from perception to action: organisms sample the world in ways that reduce uncertainty and preserve preferred states. In social settings, both partners are simultaneously predicting and acting, which produces circular causation. Second-person neuroscience emphasizes this interactive structure rather than studying an isolated observer. Flow Hijacked uses these ideas as a formal bridge, not as a settled exclusive mechanism, and asks which empirical signatures would distinguish precision reweighting from simpler learning or attentional accounts. **Theoretical anchors:** S043-S057; S152-S157

What this part must establish

- 01** The Other Is a Model, Not Only a Stimulus
- 02** Precision, Trust and the Weight of a Signal
- 03** Active Inference: Strong Language, Incomplete Discrimination
- 04** Second-Person Neuroscience

The human problem first; the mathematics only where it buys precision.

25. The Other Is a Model, Not Only a Stimulus

A face is not processed as a sequence of pixels, and a sentence is not processed as an acoustic waveform alone. Social perception is saturated with inference. We estimate intention, reliability, mood, status, danger, availability and what a response will mean for the relationship.

Those estimates are partly built from the present signal and partly from history. This is why identical words can have different effects when spoken by different people. The nervous system is not merely receiving an input; it is receiving an input through a model of the source.

Flow Hijacked places this source model inside the relational state. It can change the precision assigned to cues and the expected cost of action. A pause from a trusted person may carry low threat; the same pause from someone associated with abandonment may be amplified. The prediction is not always conscious, but it changes which trajectories become likely.

Evidence boundary

Predictive language is a formal interpretation; the same behavioral data may often be compatible with alternative models.

Evidence anchors: C31; S043, S044, S054-S057, S152-S157

26. Precision, Trust and the Weight of a Signal

Prediction alone is not enough. A system must decide how much weight to give prediction error. In predictive frameworks, precision expresses something like confidence in a signal or model. Social history can plausibly influence that weighting: whose reassurance counts, whose criticism dominates, which cue overrides which memory.

Epistemic trust adds a related developmental and clinical question. Can information from another person be treated as relevant, generalizable and safe enough to learn from? A nervous system can hear advice while assigning it almost no usable weight.

Flow Hijacked uses precision cautiously as a bridge between attachment and state dynamics. The central prediction is not that secure people possess a single high “trust

parameter.” It is that relational history can change weighting across cues, and that repair may gradually redistribute that weighting. This is testable through updating behavior, not by inventing a hidden score.

Evidence boundary

Precision weighting is a model construct, not a directly observed psychological substance.

Evidence anchors: Formal Bridge: precision weighting; S043-S044, S054-S057

27. Active Inference: Strong Language, Incomplete Discrimination

Active inference is attractive because it places perception and action inside one generative loop. An agent samples the world, updates beliefs and acts partly to make observations more consistent with preferred or expected states. In social interaction, two agents are doing this at once, each becoming part of the other’s generative environment.

That architecture can express mutual prediction, coordination, uncertainty and the value of reliable partners. It can also become unfalsifiable if every outcome is re-described after the fact as free-energy minimization.

The lecture therefore uses active inference as formal language, not a settled clinical mechanism. Its value lies in the predictions it forces us to specify: what is believed, what is observed, what actions are available, which errors are weighted and what competing model would explain the same data. The Flow Hijacked contribution begins only where those discriminations become explicit.

Evidence boundary

Distinctive empirical support remains incomplete. No active-inference-specific clinical effect size is used.

Evidence anchors: C31; NL21; S152-S157

28. Second-Person Neuroscience

Traditional social neuroscience often studies pictures of people, stories about people or judgments about people. Real interaction is different because the target responds. Your action changes my next observation; my response changes yours. The system becomes recursively coupled.

Second-person approaches try to preserve this reciprocity. They study live exchange, mutual contingency and the dynamics that exist only when both participants can affect one another. This is essential for the Borrowed Nervous System because a record-

ing of a trusted voice and the live availability of that person are not dynamically identical conditions.

The methodological price is complexity. Shared stimuli, movement, history and bidirectional causality become harder to separate. Flow Hijacked therefore treats ecological validity and identifiability as a trade-off to manage, not a choice between “real life” and “clean science.”

Evidence boundary

Live reciprocity improves ecological relevance while increasing causal-identification demands.

Evidence anchors: C03, C31; S152-S157; hyperscanning methods

PART 08

Multiple Clocks

The nervous system does not operate on one clock. Sensory responses, autonomic shifts, conversational turn-taking, working memory, learned expectations and developmental change unfold on different timescales. Relationship is therefore a multi-scale phenomenon. A two-second pause and a ten-year history can meet in the same moment. **Theoretical background**

Brains are temporally heterogeneous. Sensory circuits can respond on very short timescales, while association regions integrate information over longer windows. Intrinsic neural timescale research formalizes this hierarchy and shows that temporal integration is not uniform across cortex or state. This matters for social regulation because interaction itself spans nested clocks: a facial micro-expression, a turn in conversation, a conflict lasting minutes, a relationship history lasting years.

Fast-slow systems provide a disciplined way to represent this nesting. Fast variables may include arousal, attentional capture or moment-to-moment action; slower variables may include learned expectations, relational priors and plasticity. The small-parameter notation often used in singular perturbation theory is mathematically convenient, but the lecture does not assume that every psychological construct has a clean time constant or that attachment is literally one slow state variable. The value of the framework is organizational: it prevents a transient change from being mistaken for durable learning.

A newer frontier asks whether interaction depends not only on within-brain timescales but also on their adaptation or matching between people. The idea is plausible because conversation requires temporal coordination, but direct evidence remains much thinner than the evidence for intrinsic hierarchies within a single brain. The lecture therefore uses coupled-timescale language as a testable extension, not as an established explanation of relationship quality. **Theoretical anchors:** S099; S158-S166

What this part must establish

- 01** Intrinsic Neural Timescales
- 02** Fast Arousal, Slow Priors
- 03** Coupled Timescales: A Frontier Hypothesis
- 04** Temporal Fit in Conversation

The human problem first; the mathematics only where it buys precision.

29. Intrinsic Neural Timescales

Across cortex, neural activity shows heterogeneous temporal integration. Some systems respond and reset quickly; others integrate information over longer windows. Reviews and cross-species studies support intrinsic timescales as an organizing principle rather than a single global brain clock.

This hierarchy matters for social interaction because different operations require different windows. Rapid sensory tracking, turn-taking, mentalizing, autobiographical context and long-term relational expectation cannot all be reduced to one temporal resolution.

Flow Hijacked uses this established within-brain hierarchy as the foundation for a more speculative interpersonal question. If two people adapt to each other's temporal structure, does that change communication and regulation? The first claim is well grounded; the second remains frontier science. Keeping them separate lets novelty enter without borrowing certainty it has not earned.

Evidence boundary

Within-brain timescale hierarchy is well supported; interpersonal timescale matching is not yet an established effect.

Evidence anchors: C32; NL22; S158-S166

30. Fast Arousal, Slow Priors

A conflict can change heart rate in seconds while leaving a long-standing relational expectation intact. Repeated conflicts across months can eventually alter that expectation. This asymmetry motivates a fast-slow model.

Let faster variables describe arousal, attention, action readiness and moment-to-moment appraisal, while slower variables describe learned expectations, habits, attachment-related priors and plastic changes. The two levels interact: slow variables bias the response to each episode, and episodes feed back into slow learning.

The value of this formulation is not the symbols themselves. It forces the lecture to ask when a momentary improvement has become learning. A person can regulate beau-

tifully with a trusted other and still return to the old basin when alone. Immediate buffering and durable revision are different scientific outcomes.

$$\dot{x} = F(x, z, r) + \eta, \quad \dot{z} = \varepsilon G(x, z, r), \quad 0 < \varepsilon \ll 1$$

Evidence boundary

The separation of x and z is a Flow Hijacked multiscale model. No person-level ε is empirically identified here.

Evidence anchors: C11, C19, C32; Formal Bridge: fast-slow

31. Coupled Timescales: A Frontier Hypothesis

A 2026 framework proposes that social interaction may depend on coupling between intrinsic neural timescales. The idea is plausible: communication requires temporal compatibility, and adaptive interaction often involves prediction across multiple horizons.

But plausibility is not confirmation. There is no authorized universal effect size for person-to-person timescale matching, and the field is much newer than the evidence for intrinsic timescales within a single brain.

Flow Hijacked uses the framework as a research question. Does a trusted dyad show adaptive convergence or complementarity of temporal integration under stress? Does successful repair change the lag structure of interaction? Can temporal mismatch predict breakdown after accounting for speech rate, task structure and shared stimulus? These are experiments to perform, not conclusions to announce.

Evidence boundary

Frontier framework. No interpersonal timescale-matching effect size is authorized.

Evidence anchors: C21, C32; NL23; S099, S158-S166

32. Temporal Fit in Conversation

Good conversation has rhythm without being metronomic. People pause, overlap, wait, accelerate and slow. A distressed person may need longer latency before speech; a helper who fills every pause can unintentionally remove the temporal space required for regulation.

This is a concrete way to translate multiscale thinking without pretending to read neural timescales from ordinary behavior. Timing is itself an intervention channel. The same words delivered five seconds earlier or later can have a different effect because

the state has moved.

For Flow Hijacked, temporal fit becomes part of $C(x,y,r,t)$: coupling is explicitly time dependent. It also offers a humane clinical principle. Regulation is not always achieved by adding more content. Sometimes the system needs a different pace so that a response becomes reachable.

Evidence boundary

Conversational timing is a plausible behavioral channel; it must not be equated directly with neural timescale matching.

Evidence anchors: C21, C29; context-dependent coupling

PART 09

From Episodes to Learning

The deepest question in co-regulation is what survives the departure of the other person. Immediate buffering can be valuable even when nothing persists. But durable recovery requires more: retained change, generalization and increasing access to self-generated or network-distributed regulation. This part separates the momentary state from what the system learns from the moment. **Theoretical background**

Immediate regulation and durable learning are different outcomes. A person can feel calmer while support is present without having learned to reproduce that state later. Conversely, an interaction that is uncomfortable in the moment can still produce useful learning if it supports prediction error, agency and successful recovery. This distinction is central to developmental learning, exposure principles and plasticity more broadly.

The theoretical bridge is consolidation across timescales. Fast episodes provide data; slower systems integrate some fraction of those episodes into expectations, habits and policies for action. Repetition matters, but repetition alone is not enough. Salience, novelty, sleep, stress hormones, neuromodulatory state and behavioral consequence influence what is retained. In relational settings, this means that 'being soothed' and 'learning that distress can be survived in relationship' should not be treated as the same variable.

Flow Hijacked expresses this with a fast state x and slower state z , but the notation is deliberately schematic. The important prediction is qualitative: if repeated episodes of repair truly alter slower relational expectations, later behavior should change even when the original partner or exact context is absent. Evidence of post-interaction neural coupling is intriguing in this regard, but it remains emerging and should not be inflated into proof of durable relational plasticity. **Theoretical anchors:** S003; S006-S007; S010-

S011; S050-S051; S100

What this part must establish

- 01** Regulation Now Is Not Learning Later
- 02** What Remains When the Partner Leaves?
- 03** The Fast-Slow Relational Model
- 04** Path Dependence and Hysteresis

The human problem first; the mathematics only where it buys precision.

33. Regulation Now Is Not Learning Later

A nervous system can look better in the presence of support and return immediately to its prior pattern when support disappears. That is not failure. Acute regulation can be lifesaving or function-restoring. It is simply a different outcome from learning.

Animal studies make this distinction unusually clear: social buffering of fear can occur without later improvement in extinction under some protocols, while other work finds retained oxytocin-related buffering after partner absence. These are not direct replications, but together they warn against assuming transfer.

Flow Hijacked therefore separates four outcomes: regulation with the partner present, persistence after the partner leaves, generalization to new contexts and growth in self-generated regulation. The last three require evidence beyond the first.

Evidence boundary

Immediate buffering, retention, generalization and autonomous regulation are distinct outcomes.

Evidence anchors: C11, C22; DOI 10.1093/cercor/bhac395; DOI 10.1038/s41467-024-45626-z

34. What Remains When the Partner Leaves?

The clinically important version of this question is not whether a person becomes independent of relationship. Humans remain social. The question is whether regulation becomes less fragile and less concentrated in one specific channel.

A useful follow-up asks whether the person can later sleep, speak, make a decision, tolerate uncertainty or seek support from a broader network after the regulating encounter. These are functional signs of transfer. They are often more meaningful than whether arousal stayed low.

Emerging work on post-interaction changes in interbrain coupling raises the possibility that even brief interaction can leave measurable traces, but the evidence is still early. Flow Hijacked treats persistence as a measurement problem: define the interval, the behavior, the context and the alternative explanation before calling a trace “plasticity.”

Evidence boundary

Post-interaction persistence is emerging evidence; durable relational plasticity is not established by one study.

Evidence anchors: C22; S100; BGG outcomes

35. The Fast-Slow Relational Model

The minimal Flow Hijacked model gives the fast state x and the slower learned state z separate equations. The relational context r enters both. In the fast equation, another person can alter moment-to-moment appraisal and action. In the slow equation, repeated episodes can update expectations and regulatory capacity.

The small parameter ε is not a biological constant and should never be estimated by intuition. It simply encodes the modeling assumption that some variables change more slowly than others. Different slow processes may have different timescales.

This structure creates testable predictions. Repeated repair should change not only average distress but the response to future perturbations. If z changes, the same conflict should begin from a different expectation, show a different trajectory or recover with less external input. That is stronger evidence of learning than a calm session alone.

$$\dot{x}_i = F_i(x_i, z_i, m_i) + C_i(x_i, x_j, r_{ij}, u_i) + \eta_i, \quad \dot{z}_i = \varepsilon_i G_i(x_i, z_i, x_j, r_{ij})$$

Evidence boundary

This is a Flow Hijacked synthesis. Direct relational parameter identification remains a future research task.

Evidence anchors: C11; Formal Bridge: fast-slow

36. Path Dependence and Hysteresis

Two people can arrive at the same visible state by different histories. One calm interaction may follow months of safety; another may follow an explosive conflict and temporary suppression. The current snapshot is therefore not enough to infer the underlying landscape.

Path dependence matters because the route into a state can change the route out. A cue that is harmless after repair may be destabilizing before repair. Repeated successful transitions can also create a different history than repeated avoidance, even when both produce temporary quiet.

Hysteresis is used here as a formal possibility, not as a measured property of ev-

ery relationship. The practical intuition is simpler: history matters even when the present looks the same. Flow Hijacked therefore asks for longitudinal trajectories and perturbation-recovery profiles rather than relying only on cross-sectional scores.

Evidence boundary

Relational hysteresis is a modeling hypothesis unless directly demonstrated in longitudinal perturbation data.

Evidence anchors: C11, C24; fast-slow / social allostasis bridges

PART 10

Relational Landscapes

Once relationship is allowed into the dynamics, a new question appears: does it change only momentary response, or the repertoire of states and transitions that remain available over time? Attractor and metastability language can clarify this, provided it stays a model rather than a literal map hidden inside the brain. The point is to describe recurrence, transition difficulty and flexibility with enough precision to become testable. **Theoretical background**

Attractor language is useful because human states recur. Fear, withdrawal, approach, rumination and connection often show persistence: once entered, the system tends to remain there for a time and to return there under similar conditions. In dynamical systems, an attractor is not a metaphor for anything repetitive; it has a precise mathematical meaning tied to trajectories in state space. At person level, we rarely possess measurements rich enough to prove a literal attractor, so the lecture uses attractor language as a constrained model of recurrence.

Metastability adds flexibility. A metastable system can dwell in a regime long enough to organize behavior while remaining capable of transition. This is more compatible with healthy regulation than either complete rigidity or random switching. Empirical neuroscience increasingly studies metastable organization, but operational definitions vary. The concept should therefore not be converted into a universal wellness score.

Relational systems add a second layer. Repeated conflict, reassurance, withdrawal or repair can create dyadic regularities that resemble shared operating regimes. Social allostasis offers a way to think about how repeated coordination may shift expectations and load over time. Flow Hijacked interprets these as candidate coupled landscapes: the presence of a particular person may change transition difficulty, dwell time or recovery path. That interpretation remains a synthesis unless the relevant state space and transitions are actually estimated. **Theoretical anchors:** S061-S064; S105; S113; S145

What this part must establish

01 Attractors as Models of Recurrence

- 02** Metastability and the Width of the Repertoire
- 03** Social Allostasis and Shared Set-Points
- 04** Barrier Height and Returnability

The human problem first; the mathematics only where it buys precision.

37. Attractors as Models of Recurrence

An attractor is useful when a system repeatedly returns to a region of state space despite perturbation. In mental-health language, that can resemble recurrent threat, withdrawal, shame, craving or collapse. But the metaphor becomes misleading if every persistent feeling is declared a literal neural attractor.

Flow Hijacked uses attractor language as a model of recurrent organization. The relevant empirical questions are about trajectories: how often does the system return, how long does it dwell, what perturbation moves it, and how reliably can it come back from a disturbance?

Relationship can enter this landscape without mystical language. A predictable other may alter the trajectory after perturbation or widen the set of exits from a recurrent state. Conversely, a hostile or chaotic relationship may deepen recurrence. The data needed are time series and perturbation responses, not just labels.

Evidence boundary

Attractors are a dynamical model. Attachment, PTSD or loneliness are not asserted to be single literal neural attractors.

Evidence anchors: C08, C24; Formal Bridge: attractor

38. Metastability and the Width of the Repertoire

A system need not settle permanently into one state to be organized. Metastability describes long-lived transient regimes and the capacity to move among them. In neuroscience it is a defensible concept, but operational definitions vary and human neuroimaging studies do not share one universal metastability metric.

For Flow Hijacked, the clinically interesting quantity is not “maximum variability.” A healthy repertoire should permit flexible switching without runaway instability. Co-regulation may be valuable when it helps a person visit more states - distress, reflection, connection, action, rest - without becoming trapped in one or chaotically thrown among many.

That is why recovery is framed as expansion rather than perpetual calm. The relational field is good when it supports a broader, inhabitable repertoire with reliable

return. Metastability provides mathematical vocabulary for that possibility, not a ready-made clinical score.

Evidence boundary

Metastability is used precisely as a dynamical concept; no invented clinical “metastability score” appears.

Evidence anchors: C08; S061-S064

39. Social Allostasis and Shared Set-Points

Allostasis describes regulation through change rather than maintenance of one fixed internal value. Social-allostasis models extend this logic to groups and relationships: repeated interaction can alter what counts as normal, expected and costly inside a social system.

The idea is compelling in chronically tense families, high-conflict couples, institutions and recovery environments. A dyad can gradually normalize vigilance or, conversely, normalize repair and help-seeking. Yet “group set-point” remains partly theoretical and should not be treated as a directly measured attractor depth.

Flow Hijacked places social allostasis among slow variables. Repeated fast interactions accumulate into a changed operating range. The hypothesis is longitudinal: after repeated dysregulation or repair, the dyad should show persistence and history dependence even when the immediate trigger is held constant.

Evidence boundary

A shared social set-point is a synthesis/model, not a directly measured scalar property of a dyad.

Evidence anchors: C24; S105, S111, S113, S145; Formal Bridge: social allostatic load

40. Barrier Height and Returnability

One person can know exactly what would help and still be unable to make the transition. Speaking, leaving the room, asking for help or returning after conflict may be cognitively understood yet dynamically inaccessible. This is where barrier language becomes useful.

Barrier height is not a literal energy measurement in this lecture. It is a way to describe transition difficulty. A trusted relationship may lower the effective difficulty of moving from threat to speech, or from shame to re-entry, without eliminating distress itself.

Flow Hijacked links this to returnability: how quickly, easily and reliably can the system return to an inhabitable region after perturbation? A good relationship may mat-

ter less by preventing every dysregulation than by making return more reachable. That distinction protects ordinary human fluctuation from being mistaken for failure.

Evidence boundary

Barrier height is conceptual unless an explicit fitted state-space/energy model justifies it.

Evidence anchors: Formal Bridge: barrier height, controllability; C23

PART 11

Transient Amplification and Reachability

This is the mathematical hinge of the lecture. A stable system can still respond enormously to the right perturbation before eventually decaying. Non-normal dynamics and resolvent analysis provide rigorous tools for that phenomenon in neural and physical systems. The temptation is to transfer them directly to relationships. We resist that temptation, then use the mathematics to construct a falsifiable relational hypothesis instead. **Theoretical background**

Linear stability is often misunderstood as a guarantee of small responses. It is not. A system can have eigenvalues that predict eventual decay and still exhibit large transient amplification before it settles. One route to this behavior is non-normality: the dynamical modes are non-orthogonal, so they can combine constructively for a time even though each mode ultimately decays. This distinction is well established in fluid dynamics, control theory and recurrent neural models.

Resolvent analysis asks a related but different question: how strongly does a system amplify inputs of a given temporal frequency and direction? The resolvent depends on the operator, the frequency and the norm used. High gain does not uniquely imply non-normality; slowly decaying normal modes can also produce large resolvent values. The lecture therefore separates non-normal structure, transient growth and input-output gain rather than treating them as synonyms.

Network controllability introduces a third concept: reachability under specified inputs and a model of system dynamics. In neuroscience it has generated useful formal questions, but structural controllability metrics do not tell a clinician how to move a person between psychological states. Flow Hijacked imports only the vocabulary of reachability and control cost. The relational hypothesis is that some contexts may make alternative states easier to reach; the evidence does not yet justify a person-level numerical control energy or relational resolvent. **Theoretical anchors:** S058-S060

What this part must establish

- 01** Stable Does Not Mean Quiet
- 02** Non-Normality: A Precise Property, Not a Mood

- 03 Resolvent Gain and Direction-Specific Sensitivity
- 04 Controllability Means Reachability, Not Control of People

The human problem first; the mathematics only where it buys precision.

41. Stable Does Not Mean Quiet

Asymptotic stability answers one question: what happens as time goes to infinity after a small perturbation near an operating point? It does not tell us how large the response can become before decay. In non-normal systems, modes are non-orthogonal and can interfere constructively, creating large transient amplification even when every eigenvalue is stable.

This matters conceptually for psychiatry because people can return to baseline and still experience overwhelming intermediate excursions. It also matters for relationships: the same cue may provoke a large but transient response in one relational context and a small one in another.

The evidence boundary is essential. Non-normal transient amplification is established in neural-circuit and computational work. It has not been directly identified as a person-level relational operator. Flow Hijacked therefore imports the mathematics as a hypothesis generator, not as proof that “trauma makes the relationship matrix non-normal.”

$$\dot{q} = Aq, \quad \alpha(A) < 0 \not\Rightarrow \|e^{At}\| \leq 1 \text{ for all } t$$

Evidence boundary

Formal transfer: No person-level relational amplification factor is authorized.

Evidence anchors: C09; S058, S059; X06

42. Non-Normality: A Precise Property, Not a Mood

A linear operator A is normal when it commutes with its adjoint. Non-normality means A^*A differs from AA^* . That algebraic property allows non-orthogonal eigenvectors and can support transient amplification, but it does not guarantee it at every magnitude or timescale.

A simple upper-triangular counterexample makes the point. The matrix A_k with diagonal entries -1 and -2 remains asymptotically stable for every k . It becomes non-normal whenever k is nonzero, yet Euclidean norm growth requires $k^2 > 8$. Non-normality and large transient growth are related, not identical.

This precision protects the Flow Hijacked hypothesis from becoming metaphor. We cannot call a person or a relationship “highly non-normal” because their reactions are intense. The term earns its place only inside an identified local model with specified variables, units, inner product and time horizon.

$$A_k = \begin{pmatrix} -1 & k \\ 0 & -2 \end{pmatrix}, \quad \omega(A_k) = \frac{-3 + \sqrt{1 + k^2}}{2}$$

Evidence boundary

For this example, growth in some Euclidean direction becomes possible only when $k^2 > 8$; non-normality alone is insufficient.

Evidence anchors: C09; BGG analytical counterexample

43. Resolvent Gain and Direction-Specific Sensitivity

The resolvent asks how a stable linearized system responds to forcing as a function of frequency and direction. For an approximately stationary operator A_r , $R_r(z) = (zI - A_r)^{-1}$. An observed input-output transfer also depends on where inputs enter and what is measured: $H_r(i\omega) = C_r(i\omega I - A_r)^{-1}B_r$.

This distinction matters enormously for a relational theory. A large observed response might arise because the partner changes the input B , the observation C , the baseline state or the intrinsic dynamics A . Only the last of these supports the strongest form of Borrowed Gain Geometry.

A high resolvent norm also does not uniquely imply non-normality. A stable normal system with a slow mode can have large low-frequency gain. The hypothesis therefore requires matched spectra, timescales and competing models. “High gain” without a reference norm and frequency is not a scientific statement.

$$R_r(z) = (zI - A_r)^{-1}, \quad H_r(i\omega) = C_r(i\omega I - A_r)^{-1}B_r$$

Evidence boundary

A relational resolvent has not been measured. Input, observation and operator changes must be distinguished.

Evidence anchors: C09, C12; BGG local dynamics

44. Controllability Means Reachability, Not Control of People

Network control theory asks whether a dynamical system can be moved between states under a specified model and set of inputs, and at what formal control cost. These tools have been influential in network neuroscience. They are also easy to misuse when translated into mental-health language.

A controllability metric does not tell a therapist how to “control” a person. Linear structural models make strong assumptions, and mathematical reachability is not equivalent to behavioral freedom, clinical benefit or ethical legitimacy.

Flow Hijacked borrows the language more carefully. We ask whether some states become more reachable under a trusted relational context and whether fitted models require less input to reproduce observed transitions. Even then, autonomy remains the outcome, not an obstacle. The point of support is to widen feasible choice, not optimize another person’s trajectory without consent.

Evidence boundary

Formal reachability language only. No clinical “control energy” prescription or person-level controllability score is authorized.

Evidence anchors: C10, C12; S060; X07

PART 12

Co-Dysregulation and Coupled Traps

If people can regulate one another, they can also dysregulate one another. The relational story becomes scientifically useful only when it includes this symmetry. Synchrony can carry distress; loneliness can feed withdrawal; rejection can alter prediction; a relationship can stabilize a maladaptive equilibrium. The Other is not automatically medicine. **Theoretical background**

Co-regulation has a shadow: systems can stabilize one another in maladaptive regimes. Two people can reinforce vigilance, avoidance, substance use, rage or hopelessness through reciprocal prediction and action. This is not a moral statement about ‘toxic people’; it is a dynamical observation that feedback can amplify or maintain patterns that neither person would produce in the same way alone.

Loneliness illustrates the problem because it is both social and inferential. Objective isolation, perceived rejection, withdrawal and depressed mood are related but not identical variables. Ecological and longitudinal work suggests that loneliness can fluctuate within a person while also participating in slower reciprocal loops: expecting rejection can alter behavior, altered behavior can reduce rewarding contact, and the resulting experience can strengthen the original expectation. More contact alone is

therefore not a sufficient intervention model.

Social rejection also cautions against oversimplified neuroscience. Some studies show overlap between responses to social exclusion and systems involved in aversive or painful experience, but meta-analytic work does not support a literal one-to-one 'social pain matrix'. Distributed default-mode, salience and social-cognitive networks matter. Flow Hijacked uses the broader lesson: relational threat can narrow the accessible repertoire, but the mechanism must be specified rather than compressed into one brain region or one scalar synchrony measure. **Theoretical anchors:** S072-S073; S105; S112-S130;

S145-S151

What this part must establish

- 01** Synchronizing Into Distress
- 02** Loneliness as a Recursive State
- 03** Rejection Is Not a Single Pain Center
- 04** Boundaries Are Part of the Dynamics

The human problem first; the mathematics only where it buys precision.

45. Synchronizing Into Distress

Coupling has no moral sign. Two systems can coordinate around safety, but they can also coordinate around panic, anger, substance use, rumination or vigilance. In a high-conflict dyad, each person's defensive action may become the other's trigger, producing a self-reinforcing loop.

This is why synchrony cannot serve as a proxy for health. Co-dysregulation may look highly coordinated. The temporal relation between signals can even strengthen while the functional outcome worsens.

Flow Hijacked represents this as a coupled regime rather than a failure of one individual. That does not erase responsibility. It changes the intervention target: sometimes the loop, timing or environment must change before either person can access a different response. A system-level explanation should increase accountability by locating leverage, not diffuse it into blame-free abstraction.

Evidence boundary

Coupled-regime language is a synthesis; it does not imply a literal measured dyadic attractor.

Evidence anchors: C04, C24; X01; social allostasis

46. Loneliness as a Recursive State

Loneliness is often described as a quantity of missing contact. That misses its dynamical structure. Ecological and longitudinal work shows meaningful within-person fluctuation and links perceived rejection, withdrawal and loneliness across time. The state can change how social cues are read, which changes behavior, which changes what happens next.

Depression can enter the same loop. Low energy, anhedonia and shame reduce approach; reduced approach removes opportunities for reward and correction; isolation can deepen negative expectation. The direction is not one-way, and adding more contact does not guarantee change.

Flow Hijacked treats loneliness as a recursive multiscale state. The relevant variables include objective access, perceived quality, expectation of rejection, behavior and symptoms. This is a richer target than “number of people seen this week.”

Locked quantitative note

Loneliness-depression meta-analysis: 88 studies, N=40,068; the locked record supports a moderate significant relation but no pooled coefficient is imported here.

Evidence boundary

Association is not a one-way causal arrow; contact quantity and perceived quality must be separated.

Evidence anchors: C25, C30; X21, X22; NL20; S112-S121, S144-S151

47. Rejection Is Not a Single Pain Center

The phrase “social pain is physical pain” became popular because rejection and nociception can recruit overlapping regions and because the subjective analogy is powerful. The literal one-to-one neural claim is too strong. Meta-analyses show distributed activity involving social-cognitive, salience, default and other systems, with overlap and dissociation depending on paradigm.

The correction matters. A person who experiences rejection as physically painful is not “wrong”; phenomenology and neural identity are different questions. We can take the experience seriously without inventing a single social-pain circuit.

Flow Hijacked uses network-state language instead. Rejection changes a configuration of appraisal, memory, self-model, threat and action. The resulting state can be intensely embodied while remaining distributed. This makes room for multiple pathways of return rather than one imagined lesion or center.

Evidence boundary

No percentage overlap or literal equivalence between social rejection and physical pain is claimed.

Evidence anchors: C26; X18; S122-S130

48. Boundaries Are Part of the Dynamics

A relational framework can accidentally glorify unlimited availability. That would be both ethically poor and dynamically naïve. A relationship in which one person must continuously absorb the other's arousal can become a coupled trap of its own.

Healthy co-regulation includes boundaries, role differentiation and distributed support. One person can be important without becoming the only regulator. A therapist, partner, peer, friend and community may each carry different functions. The network is often more resilient when those functions are not concentrated in one node.

Flow Hijacked therefore includes cost to the supporter inside the system. A benefit to one person cannot be treated as success if it depends on coercion, exhaustion or loss of autonomy in another. The geometry of the other is reciprocal: both nervous systems have constraints.

Evidence boundary

Never use the framework to mandate contact, touch, availability or sacrifice from another person.

Evidence anchors: C24, C29; BGG safety/ethics

PART 13

Clinical Ecologies

Relational dynamics become clinically important when symptoms and social context begin to feed one another. PTSD can erode support while low support accompanies worse symptoms; depression can withdraw from the very sources of reward it needs; addiction can reorganize belonging and reward; anxiety and shame can narrow the social repertoire. The evidence supports reciprocal ecologies more strongly than simple one-way causes. **Theoretical background**

Clinical disorders do not occur in a social vacuum, but social variables are neither universal causes nor universal cures. PTSD provides a clear example. Social support is robustly associated with symptom severity, and longitudinal syntheses have proposed reciprocal prospective effects. Yet re-analysis shows that some directional estimates are sensitive to the statistical model. The safe conclusion is that support and symptoms are dynamically linked; the stronger claim that each directly causes future

change in the other remains contested.

Depression adds reward and withdrawal. Reduced motivation, shame and anhedonia can make contact more effortful, while reduced contact can remove opportunities for reward, corrective feedback and practical support. Addiction adds competing reinforcement, identity, group norms and access to substances. Anxiety adds threat prediction and avoidance. In each case, the social field can participate in maintenance or recovery without being the entire explanation.

This ecological view is clinically useful because it resists single-direction narratives. Symptoms can erode relationships; relationships can amplify or buffer symptoms; treatment can change both; structural conditions such as housing, work and stigma alter the available field. Flow Hijacked therefore models psychopathology as coupled ecology: person, body, relationships and environment form interacting loops. This does not dilute individual agency. It places agency inside the real system in which choices become easier, harder, safer or more costly. **Theoretical anchors:** S074-S078; S112-S121; S144-S151

What this part must establish

- 01** PTSD and Social Support: Reciprocity With a Warning Label
- 02** Depression, Withdrawal and the Vanishing Social Reward
- 03** Addiction: Belonging, Reward and Competing Fields
- 04** Anxiety, Shame and a Narrowed Relational Repertoire

The human problem first; the mathematics only where it buys precision.

49. PTSD and Social Support: Reciprocity With a Warning Label

The association between PTSD symptoms and social support is one of the strongest places to see why causal language matters. Longitudinal meta-analysis reports small prospective paths in both directions: lower support predicts later PTSD severity, and greater PTSD severity predicts later reductions in support. This fits a reciprocal loop.

But a later re-meta-analysis and simulation paper shows that cross-lagged prospective effects can be model-dependent and potentially spurious under some conditions. The correct conclusion is therefore asymmetric: the association is robust; reciprocal dynamics are plausible; directional causal magnitude is less secure.

Flow Hijacked keeps both papers side by side. Clinically, this means it is reasonable to protect social resources during PTSD while refusing to claim that a fixed amount of support will causally reduce symptoms. The social field is part of the trajectory, not a guaranteed lever.

Locked quantitative note

Longitudinal synthesis: 75 samples, N=32,402, 355 effect sizes; support→PTSD

$\beta = -.10$ and PTSD $\rightarrow$ support $\beta = -.09$. Directional causality remains contested.

Evidence boundary

The 2023 re-analysis is mandatory whenever the bidirectional coefficients are shown.

Evidence anchors: C15; X11; NL04, NL05; S074-S076

50. Depression, Withdrawal and the Vanishing Social Reward

Depression can make social life expensive at exactly the moment when isolation becomes dangerous. Anhedonia reduces expected reward; fatigue raises effort; shame predicts negative evaluation; withdrawal removes corrective and rewarding experiences. The resulting ecology can become self-reinforcing.

Social connection is associated with better psychological adjustment on average, but interventions that merely increase contact do not uniformly reduce loneliness or depression. Perceived quality, fit, belonging and symptom state matter.

The Flow Hijacked model therefore treats social withdrawal as both consequence and maintaining condition. The target is not compulsory sociability. It is restoration of reachable, tolerable and meaningful contact, with enough variability that one bad interaction does not collapse the whole field. A wider social repertoire is a form of state-space expansion.

Locked quantitative note

General social-support synthesis: 60 meta-analyses, >2,700 studies, ~2.1M participants, overall $r = .24$ [.22,.26]; adjusted subset $r = .17$ [.10,.23].

Evidence boundary

These are broad adjustment associations, not direct estimates of physiological co-regulation or a treatment effect.

Evidence anchors: C25, C30; X22; NL09, NL20; S112-S121, S144-S151

51. Addiction: Belonging, Reward and Competing Fields

Addiction is often narrated as a contest between a person and a substance. In lived systems, the substance is embedded in places, people, rituals, identities and temporal routines. Recovery therefore changes a social field as well as a pharmacological one.

Social reward matters, but it cannot be treated as a simple substitute dose. Early recovery may contain anhedonia, distrust, shame and narrowed motivation. A meeting, family contact or peer relationship can provide rhythm, expectation and borrowed future before it provides pleasure. Belonging can compete with an old attractor by changing what actions become available.

The risk is to turn one regulating network into another form of capture. Flow Hijacked therefore values recovery communities that become scaffolds rather than prisons: structures that increase agency, diversify relationships and eventually permit identity to exceed the role of “person in recovery.”

Evidence boundary

This is a Flow Hijacked synthesis across addiction, social reward and recovery ecology; it is not a claim that connection pharmacologically replaces a drug.

Evidence anchors: C06, C27, C28; social reward / opioid literature; FH recovery continuity

52. Anxiety, Shame and a Narrowed Relational Repertoire

Anxiety and shame can narrow the social field before a person consciously chooses withdrawal. Attention becomes threat-biased, ambiguous expressions become dangerous, speech becomes expensive and the number of tolerable social states shrinks. The person may still want connection while finding fewer routes into it.

A purely intrapersonal model can misread this as lack of motivation. A relational-dynamical model asks which contexts amplify threat and which permit graded approach without overwhelming cost. The aim is not to remove all anxiety before contact; it is to make more forms of contact reachable while anxiety is present.

This is where agency returns to the center. The useful outcome is not obedience to social exposure. It is the ability to choose among approach, pause, boundary, disclosure and exit with less capture by a single threat prediction.

Evidence boundary

Clinical translation is conceptual and educational; it is not an individualized exposure prescription.

Evidence anchors: C02, C23, C29, C31; attachment / predictive social inference

PART 14

Therapy as Relational Perturbation

Psychotherapy gives the relational hypothesis a demanding test. The relationship is re-

peated, bounded, observed over time and embedded in explicit attempts at change. Alliance predicts outcome robustly, but correlation is not mechanism. Ruptures matter, repair matters, and the most interesting question is whether repeated relational transitions alter what the person can do outside the room. **Theoretical background**

Psychotherapy is an unusually controlled relational setting: two people meet repeatedly, with explicit roles, boundaries and a shared task of examining and changing patterns. This makes the therapeutic relationship scientifically interesting. Meta-analyses consistently find an association between alliance and outcome across treatments, including after some measured confounds are considered. Yet association is not an isolated mechanism. Better early improvement can strengthen alliance; patient characteristics and therapist effects matter; alliance may be marker, moderator and contributor simultaneously.

Rupture and repair provide a more dynamic unit of analysis. A rupture is not simply a bad session. It is a temporary change in coordination, trust, task agreement or emotional availability. Repair requires detection, negotiation and an altered response. Meta-analytic evidence links unresolved ruptures with poorer outcome and successful resolution with better outcome, but even here causal pathways remain difficult to isolate.

Flow Hijacked interprets therapy as repeated relational perturbation only at the level of synthesis. The room can provide a structured place in which new transitions are practiced: saying what was previously hidden, remaining present during disagreement, asking for clarification, tolerating disappointment and returning after rupture. The success criterion is not perfect synchrony or permanent dependence on the therapist. It is transfer: the repertoire available in the room should become increasingly reachable elsewhere. **Theoretical anchors:** S043-S047; S066-S073

What this part must establish

- 01** Alliance Is Robust - and Not a Magic Cause
- 02** Rupture as a State Transition
- 03** Repair as Relational Learning
- 04** The Room Should Not Become the Only Safe State

The human problem first; the mathematics only where it buys precision.

53. Alliance Is Robust - and Not a Magic Cause

Few psychotherapy process variables have a literature as large as therapeutic alliance. Meta-analysis across hundreds of studies finds a reliable association between alliance and outcome, and adjusted analyses continue to show meaningful correlations after several patient and process characteristics are considered.

The temptation is to call alliance “the mechanism.” The data do not justify that singular claim. Alliance can be cause, consequence, marker, moderator or some mixture. People who begin to improve may experience the alliance differently; therapist skill

and treatment fit can influence both.

Flow Hijacked therefore treats alliance as a dynamic process variable. It tells us that the relational field matters reliably, while leaving the causal decomposition open. The mechanistic work must move from global ratings to time-resolved transitions, perturbations and repairs.

Locked quantitative note

Large synthesis: 295 independent studies, >30,000 patients, alliance-outcome $r=.278$ [95% CI .256,.299]. Adjusted estimates across 60 samples remain $r=.23-.31$.

Evidence boundary

Association is robust; singular causation is not established.

Evidence anchors: C07, C13; X08, X17; NL01, NL24

54. Rupture as a State Transition

A rupture is not simply a bad session. It is a local change in the relational state: withdrawal, confrontation, misattunement, loss of trust or disagreement about task and bond. Its importance lies partly in what follows.

Recent and canonical meta-analytic work associates ruptures with poorer outcomes and successful repair with better outcomes. That supports the clinical significance of transition and recovery, although it does not prove an attractor mechanism.

Flow Hijacked interprets rupture as a perturbation that reveals the local geometry of the therapeutic relationship. What becomes unreachable under strain? Can speech return? Does disagreement destroy the bond or become incorporated into it? The most informative data may lie in the path from rupture to repair rather than in an average alliance score.

Locked quantitative note

Rupture-repair synthesis: 11 studies, $N=1,314$, $r=.29$, $d=.62$, 95% CI [.10,.47]. Direct rupture meta-analysis: 4 publications, $N=301$, $r=-.21$.

Evidence boundary

Evidence that training specifically causes better repair outcomes is weaker; the locked training effect was not significant.

Evidence anchors: C14; NL02, NL03

55. Repair as Relational Learning

Repair becomes especially interesting when it violates an old prediction. The person expects criticism after disagreement and instead encounters curiosity. They expect distance after need and encounter a boundary that remains connected. They expect shame to end the relationship and discover that the relationship survives.

One repaired rupture does not rewrite a lifetime. Repetition matters. The fast-slow model predicts that repeated non-catastrophic repair can gradually alter slower expectations about what conflict means and which responses remain possible.

This is a Flow Hijacked synthesis, not a direct claim that a particular attachment prior or attractor depth has been measured. Its value is that it specifies what to test: changes in future response to perturbation, not only retrospective satisfaction. Repair should eventually alter trajectory, not just memory of the session.

Evidence boundary

Rupture-repair is a candidate transition-learning process, not proof of measured attractor revision.

Evidence anchors: C11, C14; fast-slow bridge; S069-S070

56. The Room Should Not Become the Only Safe State

A therapeutic relationship can function as a temporary external memory of possibility. The therapist remembers that the person has returned before, tolerates states the person cannot yet tolerate alone and helps keep future time available when it collapses. That can be profoundly regulating.

But therapy fails its broader purpose if regulation becomes possible only inside the room. The relational field should progressively support transfer into friendships, family, work, community, body routines and independent action where appropriate.

The Flow Hijacked criterion is expansion. After treatment encounters, does the person have more reachable states and more routes back from perturbation? The therapy relationship is valuable not because it becomes irreplaceable, but because it helps the wider life become inhabitable.

Evidence boundary

This is educational synthesis, not a prescription to terminate support prematurely or force independence.

Evidence anchors: C07, C11, C13, C14; transfer/generalization

PART 15

Borrowed Gain Geometry

The final part makes the novel claim as strong as it can be without pretending it is already proven. Borrowed Gain Geometry asks whether relational context can change effective gain and reachable state-space beyond differences in input, baseline, noise or observation. The proposal is useful only if it can lose. We therefore write the model, specify competing explanations, define what would count as support, and state what must never be inferred. **Theoretical background**

Borrowed Gain Geometry is the point at which the lecture deliberately moves beyond established evidence into a falsifiable Flow Hijacked proposal. The hypothesis is not that people influence one another - that is already well supported. The stronger proposal is that relational context can sometimes change the effective dynamics of response: the same perturbation may be amplified differently, alternative states may become easier or harder to reach, and recovery trajectories may change in ways that cannot be explained only by added input or a different starting state.

That claim carries a high evidential burden. A useful model must discriminate between at least five families of explanation: M0, input-only differences; M1, baseline, initial-state, noise or observation differences; M2, state-dependent gain or operating-point differences; M3, context-dependent operator or coupling changes; and M4, time-varying or delayed coupled dynamics. The more complex account earns credibility only if it improves out-of-sample prediction, survives parameter-recovery tests and remains identifiable under plausible confounds.

The formal tools in this part - local Jacobians, resolvents, finite-time propagators, controllability and non-normal amplification - are therefore not presented as clinical measurements. They define questions and experiments. The ethical criterion is equally important: a relational context is not 'good' because it suppresses arousal or increases synchrony. A beneficial geometry should enlarge safe, voluntary and agentic possibilities, including the ability to disagree, leave, return and function without coercive dependence. **Theoretical anchors:** S058-S061; S152-S166; Claim C12

What this part must establish

- 01** The Coupled Nonlinear Model
- 02** M0 to M4: Make the Strong Claim Compete
- 03** What Would Count as Evidence?
- 04** Ethics, Limits and the Geometry of Freedom

The human problem first; the mathematics only where it buys precision.

57. The Coupled Nonlinear Model

Let x_i denote faster state variables for person i , z_i slower learned or adaptive variables, m_i neuromodulatory variables and r_{ij} the relational history and context with person j . The minimal coupled model allows the other person to enter through a state- and context-dependent coupling term rather than as a fixed external force.

This formulation deliberately keeps several possibilities open. The relationship may change the operating point, input channel, coupling, parameter values, noise or observation. A difference in behavior between “alone” and “with a trusted person” is therefore not enough to establish a changed intrinsic operator.

Borrowed Gain Geometry begins only after this bookkeeping. It asks whether, after simpler explanations are modeled, the effective local dynamics themselves differ by relational context in a way that changes directional sensitivity and reachability. The equation is a research program, not a diagnostic instrument.

$$\dot{x}_i = F_i(x_i, z_i, m_i) + C_i(x_i, x_j, r_{ij}, u_i) + \eta_i$$

Evidence boundary

Novel Flow Hijacked hypothesis. No empirical relational A_r or resolvent was estimated in this project.

Evidence anchors: C12; BGG refined specification

58. M0 to M4: Make the Strong Claim Compete

The operator-change hypothesis should not be tested against a straw man. It should compete against progressively richer alternatives. M0 permits only input differences with shared dynamics. M1 adds starting state, baseline, noise and observation changes. M2 adds state-dependent gain or operating-point differences. M3 allows context-dependent operator or coupling changes. M4 permits time-varying or delayed coupled dynamics.

The logic is simple: complexity must earn its place. If M0 or M1 predicts new data as well as M3, there is no reason to announce Borrowed Gain Geometry. If the richer model improves out-of-sample prediction, survives parameter-recovery tests and remains identifiable under plausible confounds, the stronger account becomes more credible.

This hierarchy is the epistemic core of the proposal. The theory is not protected from simpler explanations; it is defined by the requirement to beat them.

$M_0 \subset M_1 \subset M_2 \subset M_3 \subset M_4$ as competing model classes, not a hierarchy of truth

Evidence boundary

Model complexity must improve prediction and identifiability; a better story is not evidence.

Evidence anchors: C12; BGG M0-M4

59. What Would Count as Evidence?

A credible experiment would manipulate relational context while controlling the input as far as possible: neutral, trusted, recorded or symbolic support; counterbalanced conditions; shared-stimulus controls; repeated measurements and multimodal outcomes. It would pre-register the competing models and test whether parameters can be recovered from synthetic data before fitting people.

The outcome should not be reduced to lower arousal. Agency-sensitive variables matter: ability to choose, speak, decline, disengage, re-engage and perform a valued action. A relational context that produces calm by suppressing choice is not a successful geometry.

The operator-specific hypothesis is weakened if simpler models predict equally well, if parameters are not identifiable, if effects fail to replicate or if the estimated “gain” vanishes when movement, respiration or expectation are controlled. A negative result would not mean relationships are unimportant. It would mean this particular mathematical claim lost - exactly as a useful hypothesis should be able to do.

Evidence boundary

Preregistered model comparison, parameter recovery and out-of-sample prediction are requirements, not optional polish.

Evidence anchors: C12; BGG evidence criteria; measurement/causal inference lane

60. Ethics, Limits and the Geometry of Freedom

The strongest version of this lecture is not “we need other people.” Human beings obviously do. The stronger claim is that relational context may alter the dynamical conditions under which agency becomes reachable. That makes ethics part of the mathematics rather than an appendix to it.

A model that optimizes calm while removing consent has optimized the wrong output. A relationship that lowers one person’s distress by exhausting another cannot be declared successful without accounting for that cost. A system that becomes stable only

through surveillance may be stable in the narrow sense and profoundly unfree.

Borrowed Gain Geometry therefore ends with a criterion: useful co-regulation widens feasible, safe and agentic trajectories. It should increase the ability to choose, return, differentiate and connect across more than one relationship. The other person matters most when their presence eventually allows more of the self - and more of the world - to become reachable.

Evidence boundary

Never use BGG to diagnose or rank relationships, mandate touch/contact, alter medication, deny care, impose surveillance or override consent.

Evidence anchors: C12; BGG safety and ethics; clinical boundary

Evidence contract

The research gate was built to prevent attractive language from outrunning evidence. The 32 major claims below are the allowed claim spine. They are deliberately mixed in status: some are direct empirical findings, some supported interpretations, some formal transfers, and one central proposal - Borrowed Gain Geometry - is explicitly novel.

C01 Relational context can alter stress physiology and regulation in humans.

Status: Parts I–IV; placement: PASS.

C02 Attachment is better treated as a history-dependent regulatory expectation th...

Status: Parts II–III; placement: PASS.

C03 Interpersonal synchrony occurs across behavior, physiology and neural signals.

Status: Part VI; placement: PASS.

C04 Higher synchrony is not intrinsically beneficial.

Status: Parts VI/XII; placement: PASS.

C05 Oxytocin should not be described as a simple trust hormone.

Status: Part V; placement: PASS.

C06 Social affiliation recruits dopamine and endogenous opioid mechanisms in addi...

Status: Part V; placement: PASS.

C07 Therapeutic relationship variables are

meaningfully associated with treatment...

Status: Part XIV; placement: PASS.

C08 Metastability is a defensible neural-dynamics concept but is operationalized ...

Status: Parts X/XV; placement: PASS.

C09 Stable recurrent neural systems can show strong transient amplification throu...

Status: Part XI; placement: PASS WITH BOUNDARY.

C10 Structural network models can quantify aspects of state controllability and c...

Status: Part X/XI; placement: PASS WITH BOUNDARY.

C11 Repeated fast relational events may alter slower learned expectations and reg...

Status: Parts VIII–IX; placement: HYPOTHESIS.

C12 Borrowed Gain Geometry: another person may alter effective gain and accessibl...

Status: Part XV; placement: HYPOTHESIS.

C13 The therapeutic alliance has a robust but not necessarily causal association ...

Status: Part XIV; placement: PASS.

C14 Alliance rupture is associated with poorer outcome, while resolved rupture is...

Status: Part XIV; placement: PASS.

C15 PTSD severity and social support are strongly linked, but the direction and c...

Status: Part XIII; placement: PASS WITH CONTRADICTION.

C16 HRV is useful for cardiac autonomic research but cannot be treated as a direc...

Status: Parts IV/XV; placement: PASS.

C17 Polyvagal Theory contains influential clinical ideas but several foundational...

Status: Part XV; placement: PASS / CONTESTED.

C18 Human oxytocin findings are heterogeneous and do not support a simple social...

Status: Part V; placement: PASS.

C19 Attachment security/insecurity is systematically related to emotion-regulatio...

Status: Parts II–III/IX; placement: PASS.

C20 Interpersonal synchrony is multimodal, modest-to-moderate in cross-level asso...

Status: Parts VI/XII; placement: PASS.

C21 Social interaction may depend on coupled intrinsic neural timescales, but thi...

Status: Parts VIII–IX; placement: FRONTIER.

C22 Brief interaction may leave measurable post-interaction changes in interbrain...

Status: Part IX; placement: FRONTIER.

C23 Familiar social proximity can reduce perceived/physiological effort and threa...

Status: Parts I/IV; placement: PASS.

C24 Dyads/groups can become locked into maladaptive coupled regulatory regimes, a...

Status: Parts X/XII; placement: PASS WITH BOUNDARY.

C25 Loneliness can behave as a recursive multi-timescale state in which perceived...

Status: Parts XII/XIII; placement: PASS.

C26 The neural response to social rejection is distributed and should not be redu...

Status: Part XII/XV; placement: PASS.

C27 Human mu-opioid signaling has a modest modulatory role in social connection b...

Status: Part V; placement: PASS.

C28 Social reward is not a single stimulus class; intimacy, immediacy, interactio...

Status: Parts V/VI; placement: PASS.

C29 Touch and verbal support can alter pain/stress responses, while mere social p...

Status: Parts III/IV/VI; placement: PASS.

C30 Loneliness, social support and depression can form mutually reinforcing clini...

Status: Part XIII; placement: PASS.

C31 Active inference offers a formal language for mutual prediction and precision...

Status: Part VII/XV; placement: PASS WITH BOUNDARY.

C32 Hierarchical intrinsic neural timescales are a well-supported organizing prin...

Status: Parts VIII–IX; placement: PASS.

Contradiction chamber

A useful theory must make its own seductive mistakes visible. These are the over-claims the lecture is designed not to make.

X01 Temptation: Synchrony is evidence of a healthy relationship.

Correction: Synchrony is a context-dependent coupling measure whose functional meaning must be independently established.

X02 Temptation: Oxytocin is the trust/love hormone.

Correction: Oxytocin modulates social salience, bonding and stress-related processes in context-dependent ways.

X03 Temptation: Attachment style determines adult psychopathology.

Correction: Attachment dimensions/representations are risk and regulatory correlates, not destiny.

X04 Temptation: HRV directly measures safety/vagal regulation.

Correction: Use HRV as one autonomic index among several, not a direct safety meter.

X05 Temptation: Inter-brain synchrony shows direct brain-to-brain information transfer.

Correction: Hyperscanning can reveal coordinated signals but directionality and causal transfer require stronger designs.

X06 Temptation: Non-normality/resolvent gain explains relational sensitivity in humans.

Correction: Use non-normality as formal transfer generating testable hypotheses about transient amplification.

X07 Temptation: Controllability metrics tell us how to move a person between psychological states.

Correction: Use controllability only as a formal language for reachability and energy; no clinical control prescription.

X08 Temptation: Therapeutic alliance is proven to be the causal mechanism of psychotherapy.

Correction: Alliance is a robust process variable that may mark and contribute to change, depending on treatment and context.

X09 Temptation: Social support is always protective.

Correction: Describe reciprocal, context-sensitive buffering and feedback.

X10 Temptation: Polyvagal theory provides a settled map of social safety.

Correction: Use basic autonomic anatomy and validated measures; audit polyvagal-specific claims separately.

X11 Temptation: PTSD and social support reciprocally cause changes in each other.

Correction: State robust association and plausible reciprocal dynamics; label directional causality contested.

X12 Temptation: More therapist-client non-verbal synchrony means a better alliance/outcome.

Correction: Treat synchrony as multidimensional and context-specific, not a monotonic therapeutic good.

X13 Temptation: Social interaction reliably raises endogenous oxytocin.

Correction: Oxytocin-sociality effects are heterogeneous and method-sensitive.

X14 Temptation: LF HRV is sympathetic tone and LF/HF is sympathovagal balance.

Correction: Do not use LF/HF as a direct balance index.

X15 Temptation: HRV is a direct measure of felt safety.

Correction: Treat vmHRV/RMSSD as constrained cardiac autonomic indicators, not phenomenological safety meters.

X16 Temptation: Polyvagal theory is a settled neurophysiological model of trauma and social safety.

Correction: Present PVT as contested; build

core autonomic account from broader physiology.

X17 Temptation: Therapeutic alliance causes good outcomes.

Correction: Alliance is a strong process marker/candidate mechanism, not a proven singular cause.

X18 Temptation: Social rejection is simply the same neural 'pain matrix' as physical pain.

Correction: Use overlap language cautiously; rejection is not reducible to nociceptive pain.

X19 Temptation: The presence of another person is sufficient to buffer pain or stress.

Correction: Specify who, how, when and

through which channel support acts.

X20 Temptation: Mu-opioid signalling is necessary for human social connection.

Correction: Describe mu-opioids as modulators, not the substrate of connection itself.

X21 Temptation: Loneliness is primarily a stable trait or a simple absence of contact.

Correction: Treat loneliness as dynamic, relational and multiscale.

X22 Temptation: Increasing social contact necessarily reduces loneliness and improves depression.

Correction: Separate access, quality, appraisal, belonging and symptom change.

Flow Hijacked formal bridge

The vocabulary below is allowed only at its stated evidential level. The purpose is to make the mathematics operational rather than decorative.

Attractor - stable/metastable region of state space. Recurring threat/safety/withdrawal relational regimes

Allowed: A useful dynamical model of recurrent states Prohibited: Attachment is literally one neural attractor

Barrier height - transition difficulty / effective landscape. Difficulty leaving threat or withdrawal state

Allowed: Can be conceptualized as altered transition difficulty Prohibited: No direct energy-landscape claim without measurement

Metastability - long-lived transient regimes. Flexible switching among relational/affective states

Allowed: Use precise metastability definition Prohibited: Do not equate all variability with metastability

Fast-slow dynamics - x fast; z slow; $\epsilon \ll 1$. Arousal/attention vs attachment priors/plasticity

Allowed: Explicitly label FH multiscale model Prohibited: Do not claim direct parameter identification

Neuromodulatory control parameters - parameter-dependent gain/plasticity/salience. OXT/DA/opioids/NE/5-HT reshape response properties

Allowed: Control parameter as systems metaphor bounded by biology Prohibited: No transmitter = emotion mapping

Non-normality - $A^*A \neq AA^*$; non-orthogonal modes. Large transient response despite asymptotic stability

Allowed: Candidate mathematical analogy / hypothesis Prohibited: No claim that relationship matrices have measured non-normal spectra

Resolvent - $R(\omega) = (i\omega I - A)^{-1}$. frequency/direction-specific amplification sensitivity

Allowed: Only inside FH hypothesis section Prohibited: Do not call it measured relational resolvent

Controllability - reachability / control energy. How accessible alternative states are under perturbation

Allowed: Use reachability language cautiously Prohibited:
No therapeutic control prescription

Precision weighting - relative confidence assigned to signals. Trust/history changes weight on threat/safety cues

Allowed: Can be framed as precision reweighting Prohibited:
Not established universal mechanism

Coupled systems - $dx/dt = F(x) + C(x, y)$. Two people mutually alter each other's trajectories

Allowed: Coupling is measurable at multiple levels Prohibited: Do not infer causal direction from synchrony alone

Social baseline / control cost - effective effort / expected resource burden. Familiar others may alter expected cost/risk of action

Allowed: Use as resource/control-cost interpretation Prohibited: Do not claim literal metabolic cost is measured in every paradigm

Social allostatic load - slow group-level set-point / accumulated regulatory burden. Repeated conflict or dysregulation may shift dyadic operating range

Allowed: Use as candidate slow-variable model Prohibited:
Do not equate group 'set-point' with measured attractor

Context-dependent coupling - $C(x, y, t)$. Coupling strength/sign depends on relationship, channel, state and time

Allowed: Explicitly reject one scalar synchrony coefficient
Prohibited: No 'more synchrony is better'

Coupled timescales - within-brain INT hierarchy + interpersonal temporal alignment. Fast mirroring and slower mentalizing/relational priors may need temporal compatibility

Allowed: Separate established INT hierarchy from social-coupling hypothesis Prohibited: Do not claim timescale mismatch is proven cause of relationship failure

Methods and integrity note

The final evidence system used for this lecture contains 380 unique records after deduplication, of which 360 were included and 20 held. The curated landmark spine contains 166 sources. Every public numerical statement is either tied to a verified pivotal publication record or forbidden by the numerical gate. Counter-evidence is preserved rather than averaged out of the story.

The project is not a preregistered systematic review and does not claim independent dual screening. Its purpose is an auditable, evidence-constrained lecture architecture. Formal transfers from non-normal dynamics, resolvent analysis and controllability remain explicitly separate from person-level empirical findings.

Borrowed Gain Geometry status. Proposed Flow Hijacked synthesis and falsifiable research program. No person-level relational non-normality, resolvent or control-energy quantity has been estimated.

Research portfolio - 360 included sources

The source portfolio below reproduces the included evidence-system records in compact form. "Spine" sources carry the principal architecture; supporting sources triangulate, constrain or contextualize it. URLs are included for provenance.

- S001** Mikulincer & Shaver. *An attachment perspective on psychopathology*. Major review. [Spine / Attachment] Boundary: Broad review; not causal proof. <https://onlinelibrary.wiley.com/doi/pdfdirect/10.1016/j.wpsyc.2012.01.003>
- S002** Long, Verbeke, Ein-Dor, Vrtička. *A functional neuro-anatomical model of human attachment (NAMA)*. Integrative social neuroscience model. [Spine / Attachment] Boundary: Model integrates heterogeneous paradigms. <https://www.sciencedirect.com/science/article/pii/S0010945220300356/pdf>
- S003** Feldman. *Sensitive periods in human social development*. Developmental review. [Spine / Attachment] Boundary: Sensitive period evidence not uniform. <https://www.cambridge.org/core/services/aop-cambridge-core/content/view/8B2635F5FD4CE2A029EAB653B5D0A212/S0954579415000048a.pdf>
- S004** Sharp & Fonagy. *The Parent's Capacity to Treat the Child as a Psychological Agent*. Developmental psychopathology review. [Spine / Attachment] Boundary: Construct measurement varies. https://discovery.ucl.ac.uk/150118/1/Fonagy_child_as_agent_template_resubmitted_12_18_WB.pdf
- S005** Luyten et al.. *Parental Reflective Functioning: Theory, Research, and Clinical Applications*. Review. [Spine / Attachment] Boundary: Theory-heavy. https://discovery.ucl.ac.uk/1498813/3/Fonagy_a_PSC_parental%20reflective%20functioningFINAL.pdf
- S006** Bick & Nelson. *Early Adverse Experiences and the Developing Brain*. Review. [Spine / Attachment] Boundary: Adversity is heterogeneous. <https://www.nature.com/articles/npp2015252.pdf>
- S007** Smith & Pollak. *Early life stress and development: potential mechanisms for adverse outcomes*. Review. [Spine / Attachment] Boundary: Mechanisms vary across exposure type. <https://jneurodevdisorders.biomedcentral.com/counter/pdf/10.1186/s11689-020-09337-y>
- S008** Olff et al.. *The role of oxytocin in social bonding, stress regulation and mental health*. Major review. [Spine / Social buffering] Boundary: Strong context dependence. <https://www.sciencedirect.com/science/article/pii/S0306453013002369/pdf>
- S009** Koolhaas et al.. *Neuroendocrinology of coping styles*. Review. [Spine / Social buffering] Boundary: Animal-to-human transfer limits. <https://research.rug.nl/files/6750004/2018FrontNeuroendocrinolKoolhaas.pdf>
- S010** van Bodegom et al.. *Modulation of the HPA Axis by Early Life Stress Exposure*. Review. [Spine / Social buffering] Boundary: Mostly developmental/preclinical integration. <https://www.frontiersin.org/articles/10.3389/fncel.2017.00087/pdf>
- S011** Koss & Gunnar. *Annual Research Review: Early adversity, HPA axis, and child psychopathology*. Major review. [Spine / Social buffering] Boundary: Developmental moderators substantial. <https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/jcpp.12784>
- S012** Cohen, Murphy, Prather. *Ten Surprising Facts About Stressful Life Events and Disease Risk*. Review. [Spine / Social buffering] Boundary: Not specific to attachment. <https://www.annualreviews.org/doi/pdf/10.1146/annurev-psych-010418-102857>
- S013** Koole. *The psychology of emotion regulation: An integrative review*. Integrative review. [Spine / Co-regulation] Boundary: Not dyad-specific. [https://research.vu.nl/files/2599118/Koole%20Cognition%20and%20Emotion%2023\(1\)%202009%20u.pdf](https://research.vu.nl/files/2599118/Koole%20Cognition%20and%20Emotion%2023(1)%202009%20u.pdf)
- S014** Lakey & Orehek. *Relational regulation theory*. Theory/review. [Spine / Co-regulation] Boundary: Theory needs mechanistic triangulation. https://research.rug.nl/files/149972773/Relational_Regulation_Theory_A_New_Approach_to_Explain_the_Link_Between.pdf
- S015** Masten et al.. *Resilience in Development and Psychopathology: Multisystem Perspectives*. Major review. [Spine / Co-regulation] Boundary: Broad framework. <https://www.annualreviews.org/doi/pdf/10.1146/annurev-clinpsy-081219-120307>
- S016** Rutten et al.. *Resilience in mental health: linking psychological and neurobiological perspectives*. Review. [Spine / Co-regulation] Boundary: Not relationship-specific. <https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/acps.12095>
- S017** Dumas et al.. *Inter-Brain Synchronization during Social Interaction*. Foundational hyperscanning experiment. [Spine / Synchrony] Boundary: Small early study; common-input concerns. <https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0012166&type=printable>
- S018** Czeszumski et al.. *Hyperscanning: A Valid Method to Study Neural Inter-brain Underpinnings of Social Interaction*. Methods review. [Spine / Synchrony] Boundary: Validity depends on null models and design. <https://www.frontiersin.org/articles/10.3389/fnhum.2020.00039/pdf>
- S019** Jiang et al.. *Neural Synchronization during Face-to-Face Communication*. Human hyperscanning experiment. [Spine / Synchrony] Boundary: Communication task specific. <https://www.jneurosci.org/content/jneuro/32/45/16064.full.pdf>
- S020** Koole & Tschacher. *Synchrony in Psychotherapy: A Review and Integrative Framework*. Review. [Spine / Synchrony] Boundary: Synchrony meaning is context-sensitive. <https://www.frontiersin.org/articles/10.3389/fpsyg.2016.00862/pdf>
- S021** Kinreich et al.. *Brain-to-Brain Synchrony during Naturalistic Social Interactions*. Naturalistic human study. [Spine / Synchrony] Boundary: Synchrony $\neq$ mechanism by itself. <https://www.nature.com/articles/s41598-017-17339-5.pdf>
- S022** Burgess. *On the interpretation of synchronization in EEG hyperscanning studies: a cautionary note*. Methods critique. [Spine / Synchrony] Boundary: Highlights spurious synchrony risks. <https://www.frontiersin.org/articles/10.3389/fnhum.2013.00881/pdf>
- S023** Azhari et al.. *Parenting Stress Undermines Mother-Child Brain-to-Brain Synchrony*. Human fNIRS study. [Spine / Synchrony] Boundary: Cross-sectional limitations. <https://www.nature.com/articles/s41598-019-47810-4.pdf>
- S024** Czeszumski et al.. *Cooperative Behavior Evokes Interbrain Synchrony: systematic review and meta-analysis*. Systematic review/meta-analysis. [Spine / Synchrony] Boundary: fNIRS-specific evidence. <https://www.eneuro.org/content/eneuro/9/2/ENEURO.0268-21.2022.full.pdf>
- S025** Kelsen et al.. *What has social neuroscience learned from hyperscanning studies of spoken communication?*. Systematic review. [Spine / Synchrony] Boundary: Heterogeneous methods. <https://www.sciencedirect.com/science/article/pii/S0149763420305650>
- S026** Hakim et al.. *Quantification of inter-brain coupling: review of current methods*. Methods review. [Spine / Synchrony] Boundary: Metric choice can change conclusion. <https://discovery.ucl.ac.uk/10176475/1/1-s2.0-S1053811923005050-main.pdf>
- S027** Goldstein et al.. *The role of touch in regulating inter-partner physiological coupling during empathy for pain*. Human experiment. [Spine / Synchrony] Boundary: Specific pain paradigm. <https://www.nature.com/articles/s41598-017-03627-7.pdf>
- S028** Reinerio, Dikker, Van Bavel. *Inter-brain synchrony in teams predicts collective performance*. Team study. [Spine / Synchrony] Boundary: Prediction $\neq$ causal control. <https://academic.oup.com/scan/article-pdf/16/1-2/43/35918854/nsaa135.pdf>
- S029** Cacioppo et al.. *The Neuroendocrinology of Social Isolation*. Major review. [Spine / Neuromodulation] Boundary: Broad causal pathways. <https://www.annualreviews.org/doi/pdf/10.1146/annurev-psych-010814-015240>
- S030** Carter et al.. *Is Oxytocin 'Nature's Medicine'?*. Critical review. [Spine / Neuromodulation] Boundary: Counters simplistic trust-hormone narrative. <https://pharmrev.aspetjournals.org/content/pharmrev/72/4/829.full.pdf>
- S031** Baskerville & Douglas. *Dopamine and Oxytocin Interactions Un-*

- derlying Behaviors*. Review. [Spine / Neuromodulation] Boundary: Much evidence preclinical. <https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/j.1755-5949.2010.00154.x>
- S032** Quintana et al.. *Oxytocin pathway gene networks in the human brain*. Human transcriptomic/network study. [Spine / Neuromodulation] Boundary: Expression $\neq$ functional causation. <https://www.nature.com/articles/s41467-019-08503-8.pdf>
- S033** Manninen et al.. *Social Laughter Triggers Endogenous Opioid Release in Humans*. Human PET study. [Spine / Neuromodulation] Boundary: Specific social behavior. <https://www.jneurosci.org/content/jneuro/37/25/6125.full.pdf>
- S034** Gordon et al.. *Oxytocin and social motivation*. Review. [Spine / Neuromodulation] Boundary: Not a universal prosocial signal. <http://www.sciencedirect.com/science/article/pii/S1878929311000727/pdf>
- S035** Grinevich & Neumann. *Brain oxytocin: how puzzle stones from animal studies translate into psychiatry*. Review. [Spine / Neuromodulation] Boundary: Human translation remains incomplete. <https://www.nature.com/articles/s41380-020-0802-9.pdf>
- S036** Aragona et al.. *A Critical Role for Nucleus Accumbens Dopamine in Partner-Preference Formation*. Preclinical causal experiment. [Spine / Neuromodulation] Boundary: Prairie vole transfer. <https://www.jneurosci.org/content/jneuro/23/8/3483.full.pdf>
- S037** Lutz & Kieffer. *Opioid receptors: distinct roles in mood disorders*. Review. [Spine / Neuromodulation] Boundary: Not social-specific. <http://www.cell.com/article/S016622361200197X/pdf>
- S038** Tarr, Launay, Dunbar. *Music and social bonding: self-other merging and neurohormonal mechanisms*. Review. [Spine / Neuromodulation] Boundary: Mechanisms partly inferential. <https://www.frontiersin.org/articles/10.3389/fpsyg.2014.01096/pdf>
- S039** Cacioppo et al.. *Loneliness*. Review. [Spine / Social threat] Boundary: Loneliness is multidimensional. [https://lirias.kul.euven.be/retrieve/d24b39a5-bbb9-441b-86fb-0c751fbdf312](https://lirias.kuleuven.be/retrieve/d24b39a5-bbb9-441b-86fb-0c751fbdf312)
- S040** Porcelli et al.. *Social brain, social dysfunction and social withdrawal*. Major review. [Spine / Social threat] Boundary: Cross-diagnostic heterogeneity. <https://www.sciencedirect.com/science/article/pii/S0149763418301957/pdf>
- S041** Kupferberg et al.. *Social functioning in major depressive disorder*. Review. [Spine / Social threat] Boundary: Association and impairment are bidirectional. <https://www.sciencedirect.com/science/article/pii/S0149763415302487/pdf>
- S042** Eslinger et al.. *The neuroscience of social feelings*. Review. [Spine / Social threat] Boundary: Broad construct coverage. <https://linkinghub.elsevier.com/retrieve/pii/S0149763421002384>
- S043** Luyten et al.. *The Mentalizing Approach to Psychopathology*. Major review. [Spine / Therapy] Boundary: Mechanistic claims vary by disorder. <https://www.annualreviews.org/doi/pdf/10.1146/annurev-clinpsy-071919-015355>
- S044** Luyten & Fonagy. *The neurobiology of mentalizing*. Review. [Spine / Therapy] Boundary: Broad neurobiology. https://discovery.ucl.ac.uk/1475516/1/Fonagy_1475516_The%20neurobiology%20of%20mentalizing%28from%20txt%20file%29.pdf
- S045** Hase & Brisch. *The therapeutic relationship in EMDR therapy*. Clinical review. [Spine / Therapy] Boundary: Modality-specific. <https://www.frontiersin.org/articles/10.3389/fpsyg.2022.835470/pdf>
- S046** Murphy et al.. *Therapeutic Alliance and Rapport Modulate Responses to Psilocybin Assisted Therapy for Depression*. Clinical study. [Spine / Therapy] Boundary: Special treatment context. <https://www.frontiersin.org/articles/10.3389/fphar.2021.788155/pdf>
- S047** Luyten et al.. *The role of mentalizing in psychological interventions in adults*. Systematic review. [Spine / Therapy] Boundary: Intervention heterogeneity. <https://discovery.ucl.ac.uk/id/eprint/10185256/1/Luyten%20et%20al%20mentalizing%20meta-analysis.pdf>
- S048** Gorlin & Békés. *Agency via Awareness: A Unifying Meta-Process in Psychotherapy*. Conceptual synthesis. [Spine / Therapy] Boundary: Conceptual rather than causal. <https://www.frontiersin.org/articles/10.3389/fpsyg.2021.698655/pdf>
- S049** Koob & Colrain. *Alcohol use disorder and sleep disturbances: a feed-forward allostatic framework*. Major review. [Spine / Clinical bridge] Boundary: Not specifically interpersonal. <https://www.nature.com/articles/s41386-019-0446-0.pdf>
- S050** Danese & Lewis. *Psychoneuroimmunology of Early-Life Stress*. Review. [Spine / Clinical bridge] Boundary: Trauma types heterogeneous. <https://www.nature.com/articles/npp2016198.pdf>
- S051** Berens, Jensen, Nelson. *Biological embedding of childhood adversity*. Review. [Spine / Clinical bridge] Boundary: Mechanistic triangulation needed. <https://bmccmedicine.biomedcentral.com/content/pdf/10.1186/s12916-017-0895-4>
- S052** Fries et al.. *Molecular pathways of major depressive disorder converge on the synapse*. Review. [Spine / Clinical bridge] Boundary: Not relationship-specific. <https://www.nature.com/articles/s41380-022-01806-1.pdf>
- S053** Beery & Kaufer. *Stress, social behavior, and resilience: Insights from rodents*. Translational review. [Spine / Clinical bridge] Boundary: Rodent-human transfer. <https://www.sciencedirect.com/science/article/pii/S2352289514000125/pdf>
- S054** Farb et al.. *Interoception, contemplative practice, and health*. Review. [Spine / Predictive / interoception] Boundary: Not dyad-specific. <https://www.frontiersin.org/articles/10.3389/fpsyg.2015.00763/pdf>
- S055** Price & Hooven. *Interoceptive Awareness Skills for Emotion Regulation*. Theory/review. [Spine / Predictive / interoception] Boundary: Intervention framework. <https://www.frontiersin.org/articles/10.3389/fpsyg.2018.00798/pdf>
- S056** Long et al.. *A functional neuro-anatomical model of human attachment (NAMA)*. Integrative model. [Spine / Predictive / mentalizing] Boundary: Not a dynamical model. <https://www.sciencedirect.com/science/article/pii/S0010945220300356/pdf>
- S057** Di Paolo & De Jaegher. *The interactive brain hypothesis*. Theory. [Spine / Predictive / mentalizing] Boundary: Formal/conceptual transfer. <https://www.frontiersin.org/articles/10.3389/fnhum.2012.00163/pdf>
- S058** Murphy & Miller. *Balanced Amplification: A New Mechanism of Selective Amplification of Neural Activity Patterns*. Theoretical/computational neuroscience. [Spine / Dynamics] Boundary: Neural circuit model; not relational evidence. <https://pmc.ncbi.nlm.nih.gov/articles/PMC2667957/>
- S059** Hennequin, Vogels, Gerstner. *Optimal control of transient dynamics in balanced networks supports generation of complex movements*. Computational neuroscience. [Spine / Dynamics] Boundary: Motor-network model; formal transfer only. <https://pmc.ncbi.nlm.nih.gov/articles/PMC6364799/>
- S060** Gu et al.. *Controllability of structural brain networks*. Network control theory / human connectome. [Spine / Dynamics] Boundary: Linear structural model; clinical transfer limited. <https://pmc.ncbi.nlm.nih.gov/articles/PMC4600713/>
- S061** La Camera et al.. *Metastable dynamics of neural circuits and networks*. Major review. [Spine / Dynamics] Boundary: Mostly circuit-level evidence. <https://pmc.ncbi.nlm.nih.gov/articles/PMC8900181/>
- S062** 2025 perspective. *Dynamical properties and mechanisms of metastability: A perspective in neuroscience*. Major perspective. [Spine / Dynamics] Boundary: Recent synthesis; not relational-specific. <https://journals.aps.org/pre/abstract/10.1103/PhysRevE.111.021001>

S063 2024 review. *Metastability demystified*. Critical review. [Spine / Dynamics] Boundary: Definitions/measures vary. <https://pubmed.ncbi.nlm.nih.gov/39663408/>

S064 Wijaya et al.. *Metastability in the wild: empirical neuroimaging scoping review*. Scoping review. [Spine / Dynamics] Boundary: Field remains methodologically heterogeneous. <https://www.sciencedirect.com/science/article/pii/S014976342500106X>

S065 Matusz et al.. *Are We Ready for Real-world Neuroscience?*. Methods perspective. [Spine / Methods / contradiction] Boundary: Real-world measures add uncontrolled variance. https://direct.mit.edu/jocn/article-pdf/31/3/327/1788382/jocn_e_01276.pdf

S066 Wampold & Horvath. *The Alliance in Adult Psychotherapy: A Meta-Analytic Synthesis*. Meta-analysis; 295 studies / >30,000 patients. [Spine / Therapy] Boundary: Robust association does not by itself establish causality 2018 Psychotherapy. https://consensus.app/papers/details/95697853cfd75bf6a32a3fb6795568c5/?utm_source=chatgpt

S067 Horvath & Wampold. *Examining therapist effects in the alliance-outcome relationship*. Multilevel meta-analysis. [Spine / Therapy] Boundary: Moderator analysis remains observational 2021 J Consult Clin Psychol. https://consensus.app/papers/details/b237a642bd1858bd82ba1778273f1c33/?utm_source=chatgpt

S068 Howard, Berry, Haddock. *Therapeutic alliance in psychological therapy for PTSD*. Systematic review + meta-analysis. [Spine / Therapy] Boundary: Included-study quality mostly weak-to-moderate 2021. https://consensus.app/papers/details/e6e06b1cf03f5ac1a2a461b32bd16944/?utm_source=chatgpt

S069 Eubanks et al.. *Alliance Rupture Repair: A Meta-Analysis*. Meta-analysis. [Spine / Therapy] Boundary: Repair association stronger than evidence for training causality 2018 Psychotherapy. https://consensus.app/papers/details/526010f234115dd395e38728e85fc5e7/?utm_source=chatgpt

S070 Babl et al.. *Alliance Ruptures and Psychotherapy Outcomes: A Multilevel Meta-Analysis*. 2026 meta-analysis. [Spine / Therapy] Boundary: Only four publications; N=301 2026 J Clin Psychol. https://consensus.app/papers/details/ee5f4cb0ab0750e3ba7196802e3ae688/?utm_source=chatgpt

S071 Aafjes-van Doorn et al.. *Therapeutic alliance and treatment outcomes in teletherapy*. Systematic review + meta-analysis. [Spine / Therapy] Boundary: Small effect and substantial heterogeneity 2024 Clin Psychol Rev. https://consensus.app/papers/details/25ceafbafd6e5d8d98265be61e548af3/?utm_source=chatgpt

S072 Jennissen et al.. *Association between nonverbal synchrony, alliance, and outcome in psychotherapy*. Systematic review + meta-analysis. [Spine / Therapy/Synchrony] Boundary: No significant overall NVS-alliance/outcome association; modality-specific effects 2024. https://consensus.app/papers/details/511a7dc2c3f45f1196a23c137ce7fc9d/?utm_source=chatgpt

S073 Atzil-Slonim et al.. *Facilitating dyadic synchrony in psychotherapy sessions*. Systematic review + meta-analysis. [Spine / Therapy/Synchrony] Boundary: Outcome association neutral-to-mildly positive; synchrony not uniformly beneficial 2023. https://consensus.app/papers/details/d7fe3373ce155dba8b57e808f300233c/?utm_source=chatgpt

S074 Wang et al.. *Social support and PTSD: A meta-analysis of longitudinal studies*. Longitudinal meta-analysis; 75 samples. [Spine / PTSD/Social support] Boundary: Cross-lag interpretation challenged by later re-analysis 2021 Clin Psychol Rev. https://consensus.app/papers/details/c0e226824ed9598fbd4fe219915e1f05/?utm_source=chatgpt

S075 Zalta et al.. *Moderators of social support and PTSD symptoms*. Meta-analysis. [Spine / PTSD/Social support] Boundary: High heterogeneity 2020/2021 Psychol Bull. https://consensus.app/papers/details/f5814a1e41375791aefa0d06924fc96a/?utm_source=chatgpt

S076 Sorjonen & Melin. *Prospective associations between social support and PTSD may be spurious*. Re-meta-analysis + simulation.

[Spine / PTSD/Social support] Boundary: Challenges prospective inference rather than cross-sectional association 2023 J Affect Disord. https://consensus.app/papers/details/9d36541aca0356109c9df4aealebb5c1/?utm_source=chatgpt

S077 Zell & Stockus. *Social support and psychological adjustment: synthesis of 60 meta-analyses*. Second-order meta-analysis. [Spine / Social support] Boundary: Effects smaller with covariate control; perceived > received support 2024/2025 Am Psychol. https://consensus.app/papers/details/37cca4eac0375ce8a773c3b46b024f08/?utm_source=chatgpt

S078 Vila. *Social Support and Longevity: Meta-Analysis-Based Evidence and Psychobiological Mechanisms*. Review of 23 meta-analyses + mechanisms. [Spine / Social support] Boundary: Support is multidimensional; confounding/moderation important 2021 Front Psychol. https://consensus.app/papers/details/6d99dbc30e00511b99567aebc5633148/?utm_source=chatgpt

S079 Laborde, Mosley, Thayer. *Heart Rate Variability and Cardiac Vagal Tone in Psychophysiological Research*. Methods/recommendations review. [Spine / Autonomic/HRV] Boundary: HRV can be misconstrued; respiration/design/reporting matter 2017 Front Psychol. https://consensus.app/papers/details/25b62a746a4e55349dd426f35cc5344a/?utm_source=chatgpt

S080 Reyes del Paso et al. / review record. *Utility of low frequency HRV as an index of sympathetic cardiac tone*. Critical review / re-analysis. [Spine / Autonomic/HRV] Boundary: LF and LF/HF are not specific sympathetic/balance indices 2013 Psychophysiology. https://consensus.app/papers/details/4e6110f14db05c50b0bc1cc160e337d4/?utm_source=chatgpt

S081 Carter et al.. *Guidelines for Rigor and Reproducibility of Heart Rate Variability*. 2026 evidence-based guidelines. [Spine / Autonomic/HRV] Boundary: HRV not a specific marker of sympathetic outflow or sympathovagal balance; vagal tone language requires caution 2026 AJP Heart. https://consensus.app/papers/details/b1acef8284785ea1b80349666e431476/?utm_source=chatgpt

S082 Roddick et al.. *Cardiac vagal recovery following acute psychological stress in adults*. Scoping review; 291 articles. [Spine / Autonomic/HRV] Boundary: Large methodological variation in timing/conditions 2025 NBR. https://consensus.app/papers/details/1cd1806dda425bb1b29331b08250ad41/?utm_source=chatgpt

S083 Porges. *Polyvagal Theory: Current Status, Clinical Applications, and Future Directions*. Proponent review. [Spine / Polyvagal audit] Boundary: Author-originated theory paper; not independent validation 2025 Clinical Neuropsychiatry. https://consensus.app/papers/details/faea082477da51eeab85bc41b5ff4b00/?utm_source=chatgpt

S084 Grossman et al.. *Why The Polyvagal Theory Is Untenable*. Multi-author critical appraisal. [Spine / Polyvagal audit] Boundary: Strong critique; should be read alongside proponent response/current account 2026 Clinical Neuropsychiatry. https://consensus.app/papers/details/e989d060ea1c507db22e035ee60e3398/?utm_source=chatgpt

S085 Doody, Burghardt, Dinets. *The Evolution of Sociality and the Polyvagal Theory*. Evolutionary critique. [Spine / Polyvagal audit] Boundary: Addresses evolutionary premise rather than all clinical claims 2023 Biological Psychology. https://consensus.app/papers/details/28a6039e9ffa57dbbad2c84c15cac916/?utm_source=chatgpt

S086 Burenkova et al.. *Endogenous Oxytocin and Human Social Interactions*. Systematic review + meta-analysis. [Spine / Neuromodulation] Boundary: Causal designs did not show expected overall hormonal response; assays/methods heterogeneous 2023 Psychol Bull. https://consensus.app/papers/details/c3443f2b16a2517eb2775a33bf70ce93/?utm_source=chatgpt

S087 Grace et al.. *Oxytocin and brain activity in humans*. Systematic review + coordinate meta-analysis. [Spine / Neuromodulation] Boundary: Effects heterogeneous across tasks and regions 2018 Psychoneuroendocrinology. https://consensus.app/papers/details/e6e4c27e80305016bc258d764999c295/?utm_source=chatgpt

S088 Peled-Avron, Abu-Akel, Shamay-Tsoory. *Exogenous effects of oxytocin in five psychiatric disorders*. Systematic review + meta-analysis. [Spine / Neuromodulation] Boundary: Small/variable clinical effects 2020 NBR. https://consensus.app/papers/details/95cee9f2142c5255979d14971fb1c41b/?utm_source=chatgpt

S089 Ellis et al.. *Developmental programming of oxytocin through early-life stress*. Four meta-analyses. [Spine / Neuromodulation/Development] Boundary: Effect sizes small; clinical samples inconsistent 2021 Clin Psychol Rev. https://consensus.app/papers/details/df5d51ced75e57619d2d5245e46bbe5d/?utm_source=chatgpt

S090 Zhang et al.. *The relationship between adult attachment and mental health*. Meta-analysis; 224 studies. [Spine / Attachment] Boundary: Association not causal destiny; moderators present 2022 JPSP. https://consensus.app/papers/details/2ce8543b05a857bba7e4fe99f4b90d3c/?utm_source=chatgpt

S091 Eilert & Buchheim. *Attachment-Related Differences in Emotion Regulation in Adults*. Systematic review; 37 studies. [Spine / Attachment] Boundary: Limited preoccupied-attachment evidence 2023 Brain Sci. https://consensus.app/papers/details/110044b6a7915cc7973294b948da18ee/?utm_source=chatgpt

S092 Cooke et al.. *Parent-child attachment and children's experience and regulation of emotion*. Meta-analytic review. [Spine / Attachment] Boundary: Does not establish direct mechanism 2019 Emotion. https://consensus.app/papers/details/19710fcc990c5da9795082a21304448f/?utm_source=chatgpt

S093 Obeldobel, Brumariu, Kerns. *Parent-Child Attachment and Dynamic Emotion Regulation*. Systematic review. [Spine / Attachment] Boundary: Only 15 studies; dynamic measurement still limited 2023 Emotion Review. https://consensus.app/papers/details/4c8e03eaa8e5735aa1bf3d4f782aea1/?utm_source=chatgpt

S094 Ohayon & Gordon. *Multimodal Interpersonal Synchrony*. Systematic review + meta-analysis. [Spine / Synchrony] Boundary: Neural-behavioral moderate; physiological-behavioral small; neural-physiological inconsistent 2024 Behav Brain Res. https://consensus.app/papers/details/76af35cd904e5e198f1262575a8b132c/?utm_source=chatgpt

S095 Zhao et al.. *Interpersonal neural synchronization in close relationships*. Systematic review + meta-analysis. [Spine / Synchrony] Boundary: fNIRS-specific; developmental moderators 2024 NBR. https://consensus.app/papers/details/36bb75b6d1565e4b8670ad404f3fba2b/?utm_source=chatgpt

S096 Mayo, Lavidor, Gordon. *Interpersonal autonomic nervous system synchrony and relationship/performance*. Systematic review + meta-analysis. [Spine / Synchrony] Boundary: Relationship effect small/marginal and highly heterogeneous 2021 Physiol Behav. https://consensus.app/papers/details/35168daede325485a69ef1f691d18cec/?utm_source=chatgpt

S097 Lavezzo et al.. *On human synchrony: parent-infant physiological and neural synchrony*. Systematic review; 42 studies. [Spine / Synchrony/Development] Boundary: Small homogeneous samples and heterogeneous pipelines 2026 NBR. https://consensus.app/papers/details/fd76c8bcd6dc53edb3a49a8abd642f3c/?utm_source=chatgpt

S098 Birk, Stewart, Olino. *Parent-Child Synchrony After Early Childhood*. Systematic review; 37 studies. [Spine / Synchrony/Development] Boundary: Context can flip association with outcomes 2022 Clin Child Fam Psychol Rev. https://consensus.app/papers/details/1s/0d0d519f35695fb0857b0d68be988298/?utm_source=chatgpt

S099 Wolff & Dumas. *Coupled neural timescales in social interaction*. 2026 Trends review. [Spine / Timescales] Boundary: Frontier framework; proposed mechanism not yet established 2026 Trends Cogn Sci. https://consensus.app/papers/details/417f9a7159435a1282e9c21502f5f7c6/?utm_source=chatgpt

S100 Shamay-Tsoory et al.. *Post-interaction neuroplasticity of inter-brain networks*. Human fNIRS study. [Spine / Synchrony/Plasticity] Boundary: Single-study evidence; interpretation of 'plasticity' requires caution 2024 iScience. <https://consensus.app/papers/d>

etails/b340c2e5ab1857bb81dade5172ba1063/?utm_source=chatgpt

S101 Holt-Lunstad, Smith, Layton. *Social Relationships and Mortality Risk: A Meta-analytic Review*. Meta-analysis. [Spine / Social support] Boundary: Observational mortality literature; mechanisms not isolated Landmark general social-health anchor. <https://journals.plos.org/plosmedicine/article/file?id=10.1371/journal.pmed.1000316&type=printable>

S102 Coan & Sbarra. *Social Baseline Theory: The Social Regulation of Risk and Effort*. Integrative theory/review. [Spine / Social baseline] Boundary: Theory contains hypotheses beyond direct evidence 2014. https://consensus.app/papers/details/96e4a2c6ec2c5011a3063b621ccd0320/?utm_source=chatgpt

S103 Beckes & Coan. *Social Baseline Theory: The Role of Social Proximity in Emotion and Economy of Action*. Theory/review. [Spine / Social baseline] Boundary: Some propositions explicitly speculative 2011. https://consensus.app/papers/details/885e0ac329dd5573a177336d51610b07/?utm_source=chatgpt

S104 Beckes & Sbarra. *Social baseline theory: State of the science and new directions*. Review. [Spine / Social baseline] Boundary: Framework-level, not a single mechanism 2021. https://consensus.app/papers/details/f18a0d92e2bd591f9cb9cdd5926ea7a/?utm_source=chatgpt

S105 Saxbe, Beckes, Stoycos, Coan. *Social Allostatic and Social Allostatis Load*. Theory/review. [Spine / Social allostatis] Boundary: Group-level allostatic load remains a model requiring tests 2019/2020. https://consensus.app/papers/details/f30c82fca0cb54db86a912f9ea4eaf6d/?utm_source=chatgpt

S106 Eisenberger. *Neural Underpinnings of Receiving and Giving Social Support*. Neuroscience review. [Spine / Social support neuroscience] Boundary: Neuroimaging associations do not isolate causal pathways 2013. https://consensus.app/papers/details/ee792cde0af356be89c34a82697c35fd/?utm_source=chatgpt

S107 Gong et al.. *Social support facilitates threat extinction retention in humans*. Human experimental fMRI study. [Spine / Social buffering] Boundary: Single paradigm; replication/generalization needed 2025 Translational Psychiatry. https://consensus.app/papers/details/5b2fe55aca165c2883de17a961f7e132/?utm_source=chatgpt

S108 Maffei et al.. *Physical Proximity With Social Support Regulates Vigilance to Threat*. Human TSST psychophysiology experiment. [Spine / Social buffering] Boundary: Small sample and specific stressor 2026 Psychophysiology. https://consensus.app/papers/details/ca36bdb57f4e5bdabd7f2f39d1d9a258/?utm_source=chatgpt

S109 Gonzalez et al.. *Yielding to social presence as a bioenergetic strategy*. Human fMRI + theoretical synthesis. [Spine / Social baseline] Boundary: Specific operationalization; needs broader replication 2021. https://consensus.app/papers/details/3169d3dd8f78584eb61a496ceeeae333/?utm_source=chatgpt

S110 Gross & Medina-DeVilliers. *Cognitive Processes Unfold in a Social Context*. Review. [Spine / Social baseline] Boundary: Extension of SBT remains theory-guided 2020. https://consensus.app/papers/details/fcb5de677bc75bb09f21b852b65a3e45/?utm_source=chatgpt

S111 Bar-Kalifa & Rafaeli. *Above and below baselines*. Dyadic diary studies. [Spine / Social baseline] Boundary: Small dyadic samples 2015. https://consensus.app/papers/details/9edad7a4708157018fd8e026966d569c/?utm_source=chatgpt

S112 Lam et al.. *Neurobiology of loneliness: a systematic review*. Systematic review; 41 studies. [Spine / Loneliness] Boundary: Methods and directions heterogeneous 2021 Neuropsychopharmacology. https://consensus.app/papers/details/2c825d46669051a6ae43dab1d51dbd/?utm_source=chatgpt

S113 Shao et al.. *Loneliness modulates social threat detection in daily life*. EMA + dynamic structural equation models. [Spine / Loneliness dynamics] Boundary: N=157; observational within-person dynamics 2026 Communications Psychology. https://consensus.app/papers/details/57b0001ed71d550fa1e23dd88d02f634/?utm_source=chatgpt

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- S114** Lasgaard et al.. *Are loneliness interventions effective?*. Preregistered meta-analysis; 280 studies. [Spine / Loneliness intervention] Boundary: GRADE low/very low; heterogeneity 2025/2026 American Psychologist. https://consensus.app/papers/details/43fd874098eb570799c252213717da36/?utm_source=chatgpt
- S115** Barjaková, Garneró, d'Hombres. *Risk factors for loneliness*. Review emphasizing meta/longitudinal evidence. [Spine / Loneliness] Boundary: Mostly Europe/North America 2023 Social Science & Medicine. https://consensus.app/papers/details/7a425bb9fcd756f29e2cc8fcb00d2be8/?utm_source=chatgpt
- S116** Luo & Shao. *Positive and negative emotion functions related to loneliness*. Systematic behavioral/neuroimaging review. [Spine / Loneliness] Boundary: Brain directionality mixed 2023 Psychoradiology. https://consensus.app/papers/details/21999a7ca98c50f9b644412e07cb7f4e/?utm_source=chatgpt
- S117** Mann et al.. *Loneliness and the onset of new mental health problems*. Systematic review + meta-analysis longitudinal cohorts. [Spine / Loneliness] Boundary: Heterogeneity; causality not fully established 2022. https://consensus.app/papers/details/accc04ed81af50cfa00d662475deab26/?utm_source=chatgpt
- S118** Erzen. *The effect of loneliness on depression: A meta-analysis*. Meta-analysis; 88 studies. [Spine / Loneliness/Depression] Boundary: Predominantly correlational literature 2018. https://consensus.app/papers/details/15d9cf69a331526e896e896a84601335/?utm_source=chatgpt
- S119** Wang et al.. *Loneliness/social support and outcomes of mental health problems*. Systematic review of longitudinal studies. [Spine / Social support clinical] Boundary: Clinical populations heterogeneous 2018 BMC Psychiatry. https://consensus.app/papers/details/a0e63638d20d55038a579d84a6abc506/?utm_source=chatgpt
- S120** Hajek et al.. *Loneliness and social isolation in severe mental disorders*. Systematic review + meta-analysis. [Spine / Loneliness clinical] Boundary: Very high heterogeneity; few longitudinal studies 2025. https://consensus.app/papers/details/89cce8e03c405363a5165edfd88ab6a3/?utm_source=chatgpt
- S121** Vazquez Alvarez et al.. *Social connection interventions and depression in young adults*. Systematic review + meta-analysis. [Spine / Social intervention] Boundary: Only six studies; modest effects 2024. https://consensus.app/papers/details/5e5a4311c2d95aa082a32edaef981a66/?utm_source=chatgpt
- S122** Cacioppo et al.. *Quantitative Meta-Analysis of Functional Imaging Studies of Social Rejection*. Neuroimaging meta-analysis. [Spine / Social rejection] Boundary: Older literature and task heterogeneity 2013 Scientific Reports. https://consensus.app/papers/details/ef557745f64e5880a3c927f2e178041a/?utm_source=chatgpt
- S123** Mwilambwe-Tshilobo & Spreng. *Social exclusion reliably engages the default network*. ALE meta-analysis; 53 studies, N=1817. [Spine / Social rejection] Boundary: Cyberball-specific evidence 2020 NeuroImage. https://consensus.app/papers/details/8af26cb19b22517d9f70a097d651d4b2/?utm_source=chatgpt
- S124** Rotgé et al.. *Anterior cingulate contribution to social pain*. Voxel-based meta-analysis; 46 articles. [Spine / Social rejection] Boundary: Task and age moderators 2014. https://consensus.app/papers/details/d75c1cc3e1295ffca22b1614ec23e1aa/?utm_source=chatgpt
- S125** Vijayakumar, Cheng, Pfeifer. *Neural correlates of social exclusion across ages*. Coordinate meta-analysis. [Spine / Social rejection] Boundary: Developmental paradigms heterogeneous 2017 NeuroImage. https://consensus.app/papers/details/35ca66ac23ac54c29b2ec2a5cbd873a1/?utm_source=chatgpt
- S126** Atzil et al.. *Impact of sociality and affective valence on brain activation*. Meta-analysis; 614 contrasts. [Spine / Social affect] Boundary: Meta-analytic categories broad 2023 NeuroImage. https://consensus.app/papers/details/6eec63e0ecaf59c3ac4550e809ee43b8/?utm_source=chatgpt
- S127** Quarmley et al.. *Effects of Social Rejection on Aggressive and Prosocial Behavior*. Meta-analysis. [Spine / Social rejection] Boundary: Experimental rejection paradigms may not generalize to enduring relationships 2022. https://consensus.app/papers/details/e5bb405a8e250ceb7b5b202f916f5cf/?utm_source=chatgpt
- S128** Feng et al.. *Common brain networks underlying human social interactions*. Large-scale neuroimaging meta-analysis; 7234 participants. [Spine / Social networks] Boundary: Task-based inference only 2021 NBR. https://consensus.app/papers/details/97c4e043f1ca5952a2fac58d0aafcca4/?utm_source=chatgpt
- S129** Zhang et al.. *Neural mechanisms of physical and social pain empathy*. ALE meta-analysis. [Spine / Social pain empathy] Boundary: Empathy ≠ first-person rejection 2025 Cerebral Cortex. https://consensus.app/papers/details/39fd7e206e2d575a937048f4dd851dd0/?utm_source=chatgpt
- S130** Lamm, Decety, Singer. *Common/distinct networks for pain and pain empathy*. Meta-analysis. [Spine / Empathy] Boundary: Not direct evidence for social rejection 2011 NeuroImage. https://consensus.app/papers/details/155eb5ff2b15592784841785d7cb5d93/?utm_source=chatgpt
- S131** Løseth, Trøstheim, Leknes. *Endogenous mu-opioid modulation of social connection in humans*. Preregistered systematic review + meta-analysis. [Spine / Social reward] Boundary: Effect modest; possible small-study/publication bias 2024 Translational Psychiatry. https://consensus.app/papers/details/dab72c1986f85424b2a00325118a3278/?utm_source=chatgpt
- S132** Stijovic et al.. *Defining social reward*. Systematic review; 384 studies. [Spine / Social reward] Boundary: Field definitions highly heterogeneous 2024 Psychological Bulletin. https://consensus.app/papers/details/fba379602ebb53be969ccef3ecef5bb1/?utm_source=chatgpt
- S133** Massaccesi et al.. *Effects of dopamine and opioid receptor antagonism on social/nonsocial rewards*. Randomized double-blind pharmacology + fMRI. [Spine / Social reward] Boundary: Behavioral effects limited; neural effects context-specific 2023/2024 Human Brain Mapping. https://consensus.app/papers/details/4150a40176765e8386d3b91850f0fed8/?utm_source=chatgpt
- S134** Inagaki et al.. *Opioids and social bonding: naltrexone, connection and ventral striatum*. Randomized placebo-controlled fMRI study. [Spine / Social reward] Boundary: N=80; one antagonist paradigm 2019/2020 JEP General. https://consensus.app/papers/details/2c5169cc68ae50f085e5df3abfb074e5/?utm_source=chatgpt
- S135** Korb et al.. *Dopaminergic and opioidergic regulation during social and nonsocial rewards*. Randomized pharmacological experiment. [Spine / Social reward] Boundary: Subjective ratings not strongly modulated 2020 eLife. https://consensus.app/papers/details/7afcf04167dfa5026a7c6e416354a9fec/?utm_source=chatgpt
- S136** Pellissier et al.. *Mu opioid receptor; social behaviour and autism spectrum disorder*. Review. [Spine / Social reward] Boundary: Substantial preclinical translation 2018 BJP. https://consensus.app/papers/details/b9377449c9d65afdbf1260f9802db043/?utm_source=chatgpt
- S137** Kraus, Výborová, Silani. *Intranasal oxytocin on social reward processing in humans*. Systematic review. [Spine / Social reward] Boundary: Mixed human effects; 19 studies 2023 Front Psychiatry. https://consensus.app/papers/details/d682bc214f0f5dc2be381a8c161ca5b9/?utm_source=chatgpt
- S138** Venniro et al.. *Protective Effect of Social Reward on Opioid and Psychostimulant Reward and Relapse*. Mechanistic review. [Spine / Addiction/Social reward] Boundary: Primarily rodent evidence 2022 J Neurosci. https://consensus.app/papers/details/468ec63245065695839447532bf04e02/?utm_source=chatgpt
- S139** Che et al.. *Social support on experimental pain and physiological arousal*. Systematic review + meta-analysis. [Spine / Touch/Pain] Boundary: Mere presence not sufficient; context matters 2018 NBR. https://consensus.app/papers/details/e92451a7805b587a8f1a1da6e0ec5d70/?utm_source=chatgpt

- S140** Che et al.. *Processes underlying buffering effect of social support on pain*. Systematic review. [Spine / Touch/Pain] Boundary: Only five neurobiological studies 2018 Clinical Journal of Pain. https://consensus.app/papers/details/9ebbb17da253512d811248cbc9f9e564/?utm_source=chatgpt
- S141** Packheiser et al.. *Physical and mental health benefits of touch interventions*. Large multilevel meta-analysis; 137 randomized studies. [Spine / Touch] Boundary: Metadata/journal to be rechecked at publication-level lock Large effect-synthesis anchor; metadata verification pending. https://consensus.app/papers/details/f2441106ae3a58f68c897d7340598e22/?utm_source=chatgpt
- S142** Rinaudo, Steyaert, Mouraux. *Social support and chronic pain*. Systematic review. [Spine / Pain/Social support] Boundary: Mostly cross-sectional/correlational 2025 PLOS One. https://consensus.app/papers/details/4809596d01c75f2c8bb11a261b03961d/?utm_source=chatgpt
- S143** Wilson et al.. *Peer support for chronic musculoskeletal pain*. Systematic review + meta-analysis of randomized trials. [Spine / Pain/Peer support] Boundary: Low/very-low certainty; effects small 2024 Pain. https://consensus.app/papers/details/a1e815b72163555c8cd70dce1d714bae/?utm_source=chatgpt
- S144** Wang et al.. *Social support and outcomes of mental health problems*. Longitudinal systematic review. [Spine / Depression/Social support] Boundary: Heterogeneous measures/populations 2018. https://consensus.app/papers/details/a0e63638d20d55038a579d84a6abc506/?utm_source=chatgpt
- S145** Achterbergh et al.. *Experience of loneliness among young people with depression*. Qualitative meta-synthesis. [Spine / Depression/Loneliness] Boundary: Qualitative; young samples 2020 BMC Psychiatry. https://consensus.app/papers/details/4dbefefb3fb6536ab663f98829e8d8f9/?utm_source=chatgpt
- S146** Vazquez Alvarez et al.. *Social connection interventions and depression in young adults*. Systematic review + meta-analysis. [Spine / Depression/Social intervention] Boundary: Small evidence base 2024. https://consensus.app/papers/details/5e5a4311c2d95aa082a32edaef981a66/?utm_source=chatgpt
- S147** Hajek et al.. *Loneliness/social isolation in severe mental disorders*. Systematic review + meta-analysis. [Spine / Clinical social ecology] Boundary: Extremely high heterogeneity 2025. https://consensus.app/papers/details/89cce8e03c405363a5165edfd88ab6a3/?utm_source=chatgpt
- S148** Mann et al.. *Loneliness and new onset mental health problems*. Longitudinal systematic review + meta-analysis. [Spine / Loneliness/Depression] Boundary: Residual confounding and heterogeneity 2022. https://consensus.app/papers/details/accc04ed81af50cfa00d662475deab26/?utm_source=chatgpt
- S149** Erzen. *Loneliness effect on depression*. Meta-analysis. [Spine / Depression/Loneliness] Boundary: Causality not secured 2018. https://consensus.app/papers/details/15d9cf69a331526e896e896a84601335/?utm_source=chatgpt
- S150** Hajek et al.. *Chronic loneliness and social isolation among older adults*. Systematic review/meta-analysis/meta-regression. [Spine / Loneliness] Boundary: Limited longitudinal evidence 2024. https://consensus.app/papers/details/2753f973c37c5611b22a41aaeff4b85/?utm_source=chatgpt
- S151** Zagic et al.. *Interventions to improve social connections*. Systematic review + meta-analysis controlled trials. [Spine / Social intervention] Boundary: Different interventions affect different dimensions 2021/2022. https://consensus.app/papers/details/8365df6fa38b57db98ac17b4a624e720/?utm_source=chatgpt
- S152** Lehmann et al.. *Active-Inference Approach to Second-Person Neuroscience*. Theoretical review grounded in second-person neuroscience. [Spine / Predictive social cognition] Boundary: Active-inference interpretation exceeds direct empirical evidence 2023/2024. https://consensus.app/papers/details/36d862d89bf95f09901a2414871f35b3/?utm_source=chatgpt
- S153** Pezzulo, Parr, Friston. *Active inference as a theory of sentient behavior*. Major theoretical review. [Spine / Predictive processing] Boundary: Unifying framework remains debated and incompletely tested 2024. https://consensus.app/papers/details/d17124f0ff8f5d88ae54d5710a2b2a3b/?utm_source=chatgpt
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Closing synthesis

The central claim of this lecture is deliberately narrower than the phrase “we regulate one another” and broader than the idea that support merely adds comfort. Human nervous systems remain individual, embodied and historically structured, yet they operate inside contexts that can change appraisal, expected cost, salience, learning and the accessibility of action. The scientific task is not to replace the individual with the relationship. It is to model the relationship as one of the conditions under which the individual system moves.

That distinction protects agency. A useful account of co-regulation should never imply

that another person owns the trajectory, that dependence is automatically healthy, or that reduced arousal is the universal objective. Regulation can be shared while choice remains personal. A relationship can help widen the field by making speech, rest, action, disagreement or recovery more reachable; it can also narrow the field through coercion, threat, over-accommodation or mutual dysregulation. The sign of a beneficial relational process is therefore not maximal synchrony. It is a wider repertoire with preserved consent.

The mathematical language developed here is valuable only when it sharpens that question. Attractors describe recurrence; metastability describes flexible residence and switching; fast-slow dynamics separates immediate state change from slower learning; non-normality and resolvent analysis distinguish eventual stability from transient sensitivity; controllability provides a cautious language for reachability and cost. None of these constructs licenses a diagnosis of a person or relationship. They are tools for building and testing models.

Borrowed Gain Geometry is the most ambitious proposal in the lecture and therefore receives the strictest boundary. Its claim is not that relationships matter. Its claim is that, under some conditions, relational context may alter effective gain or reachable state-space beyond what can be explained by input, baseline, noise or observation alone. That possibility must earn its place empirically by outperforming simpler models, surviving confound controls and producing reproducible predictions. If it fails those tests, the practical value of supportive relationships remains intact; only the stronger operator-level account is weakened.

The humane endpoint is simple. Autonomy is not the absence of influence. It is an increasing capacity to use influence without surrendering authorship: to accept regulation without becoming owned by it, to borrow stability without making one bond indispensable, and to carry what was learned into a wider field of life.

Final sentence

A borrowed nervous system has done its best work when what was once reachable only together becomes increasingly reachable by the person, through a wider and freer field of life.