

117-267-D Gudiya Cognitive Coordinate System V2

Functional Necessity and the Unfinished Geometry of Cognitive Orientation

CCS is functionally necessary but structurally unfinished.

A foundational chapter by the Stability Engineering Institute

Version 2 September 2026

This second formulation incorporates the External Reference Principle, field-relative motion, cognitive dead reckoning, MagNav evidence, Actant Cognitive Signatures, transient AI teams, the Grid as a federated reference, and a testable research program for Cognitive Cartography.

The conclusion reached by Version 2

The August 2026 chapter proposed that actants require a coordinate system through which they can determine their identity, direction, motion and stability relative to the GUDIYA Grid. Subsequent work has strengthened the need for such a system while making clear that its final geometry has not yet been discovered.

The need for a Cognitive Coordinate System is established by systems engineering logic. Its final axes, landmarks, transformations and measurement rules remain an open research problem.

This distinction matters. It separates a defensible necessity claim from premature specification. Version 2 therefore treats the coordinate list in the original chapter as a set of candidate observable families, not as a finished Cartesian scheme.

What changed after the August formulation

- The External Reference Principle became the primary rationale: dynamic relative motion cannot be oriented reliably from an actant's internal viewpoint alone.
- The difference between internal state and systemic position became explicit. A complete internal history can still yield the wrong conclusion about an actant's place in a collective.
- Time became a first class variable. Position without epoch, phase and observation age is not a usable coordinate.
- Field-relative motion replaced a single absolute-speed metaphor. The same actant can be nearly stationary in one frame and moving rapidly in another.
- Transient AI teamwork showed why persistent system architecture is insufficient. Team membership, coupling and coordination burden can change faster than the underlying System of Systems.
- The MagNav flight supplied a concrete operational analogue: internal navigation drifts, while recurring fixes from an external field and reference map bound the error.
- The CCS was repositioned as a federated orientation service. It need not become a central command mechanism that directs every actant.

The scope of the claim

CCS does not claim that cognition occupies ordinary physical space or that cognitive variables already possess agreed units. It proposes that a sufficiently observable agentic ecosystem can be represented in a reference framework that supports relative location, motion, uncertainty and stability assessment. The scientific task is to determine which representations remain valid across actants, domains and timescales.

The External Reference Principle

A moving system can estimate its condition internally, but internal integration accumulates error. This is familiar in navigation, control, finance and distributed computing. The problem becomes more severe when several moving entities estimate one another while their observations arrive at different rates and with different delays.

Dynamic relative motion requires an external reference.

For an AI actant, the term motion includes changes in objective, authority, state, cognitive velocity, coupling, influence, workload and stability margin. None of these changes is fully interpretable from the actant's local narrative. The actant may know what it intended and what it executed while remaining unaware of downstream amplification, newly formed dependencies or a shift in the collective state.

Three reference frames

CCS must distinguish at least three frames. The actant frame contains the local model, memory and objective. The team frame contains current membership, shared task state and mutual dependencies. The Grid frame supplies continuity across teams, enterprises and domains. A coordinate statement is incomplete unless it identifies both its frame and its time.

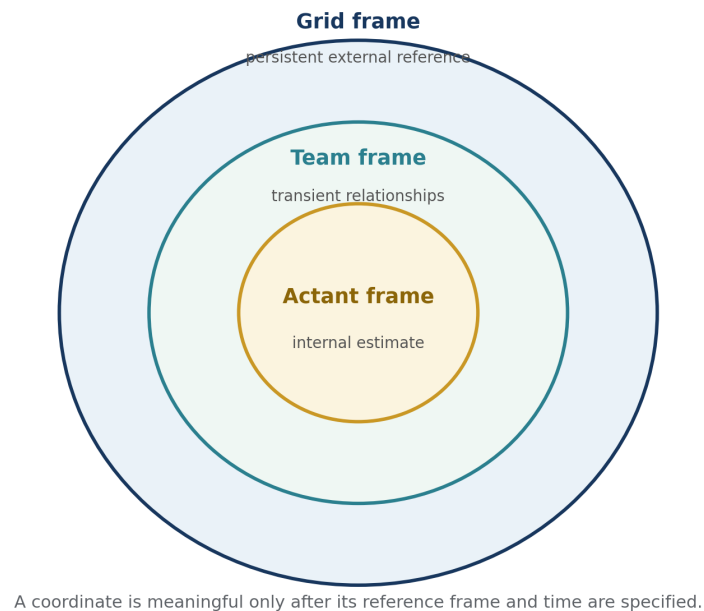


Figure 1 Candidate reference frames for cognitive orientation

Ground speed and airspeed for cognition

An aircraft can have one velocity relative to the ground and another relative to the surrounding air. Both are correct, but they answer different questions. An agent likewise has execution speed relative to its own task, coordination velocity relative to its current team, and field-relative motion relative to the

wider ecosystem. CCS must name the reference frame before assigning meaning to cognitive speed, altitude, drift or direction.

MagNav and the cognitive navigation problem

In 2026, a Honeywell and Defense Innovation Unit test aircraft completed a four hour and twenty three minute GPS-denied flight over the Pacific using magnetic navigation. The reported system compared locally sensed magnetic variations with a reference map and achieved substantially better position accuracy than conventional backup navigation methods. The event does not test CCS, but it demonstrates the engineering pattern on which CCS rests. [1]

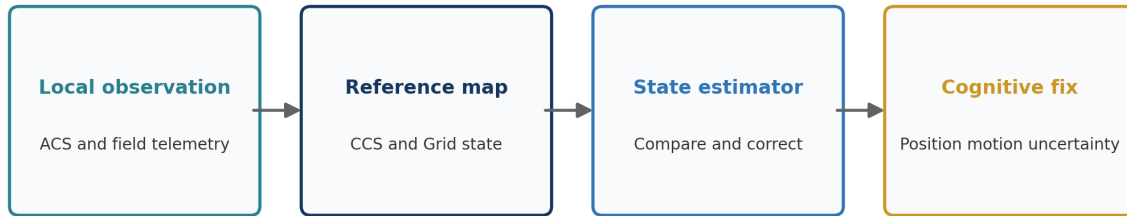
Magnetic navigation	Cognitive orientation
Aircraft	Actant
Inertial estimate	Internally estimated cognitive state
Accumulated navigation error	Cognitive drift and state divergence
Local magnetic signature	Actant Cognitive Signature and field telemetry
Magnetic reference map	Maintained CCS reference model
Map matching and correction	Grid state estimation and cognitive fix
Position uncertainty	Coordinate confidence and observation age

The MagNav correction to the original theory

The original chapter emphasized the Universal Cognitive Grid Pulse as the North Star of the coordinate system. Version 2 assigns UCGP a narrower and more defensible role: it can provide epoch, phase and synchronization reference, but it need not supply every coordinate. MagNav shows that an ambient field can support local orientation when combined with sensing, a trusted map and an estimator. A continuous global broadcast is not the only possible architecture.

A field does not become a coordinate system merely because it exists. It becomes navigable when observable signatures can be compared with a maintained reference map.

The CCS navigation chain



The field alone is insufficient. Orientation requires sensing, a maintained map, and an update rule.

Figure 2 The functional chain required for a CCS position fix

Cognitive dead reckoning

Dead reckoning estimates present position by integrating previous position with measured motion. It remains useful, but its error grows when measurements contain bias or when the environment changes. Long-running headless agents face an analogous condition. They integrate prompts, memories, tool outputs, delegated tasks and unfinished objectives into a continuing internal state. No automatic reset occurs merely because one task ended and another began.

The result is path dependence. Software at time t plus one may behave differently from the same software at time t even when no code has changed. State accumulation, unresolved commitments and previous interactions alter the next decision. Internal coherence does not guarantee correct external orientation.

Sources of cognitive navigation error

Source	How error accumulates	CCS response
State persistence	Old context and unfinished work continue to influence later actions.	Track lineage, state age and unresolved objectives.
Asymmetric cognition velocity	Actants update at different rates and reason from different snapshots.	Record observation time, phase and relative velocity.
Recursive delegation	Derived agents extend a plan beyond the originating actant's current awareness.	Preserve ancestry, authority and intent continuity.
Implicit coupling	Queues, databases, markets and shared resources connect agents that never exchange messages.	Map indirect dependencies and inferred influence.
Environmental change	A previously correct belief becomes obsolete while remaining internally consistent.	Compare local belief with current Grid observations.
Transient membership	The relevant team changes during execution.	Recalculate team frame, proximity and coordination burden.

The Cognitive Position Fix

A Cognitive Position Fix is a time-stamped Grid estimate that compares an actant's predicted state with externally observed evidence. The correction need not replace the actant's reasoning. It can update confidence, identify frame disagreement, reduce permitted gain, request clarification, slow a rendezvous or trigger quarantine when uncertainty exceeds the approved envelope.

In conceptual form:

Predicted state + external observation + reference map -> corrected position with uncertainty

Functional necessity and unfinished structure

CCS can be necessary before its coordinate geometry is known. Aviation required reliable orientation before every modern navigation sensor, projection and reference standard had been invented. The current claim is therefore functional: agentic systems need a way to obtain external, time-aware estimates of their relational condition. Research must determine the most useful representation.

Established requirement	Open structural question
External reference	Which observations remain independent enough to correct local drift?
Time awareness	Should epoch, phase, age and horizon be separate coordinates or metadata?
Relational location	How should cognitive distance and proximity be defined across unlike actants?
Motion estimation	Which measures of velocity, direction and acceleration predict consequential change?
Uncertainty	How should confidence combine missing data, stale data and model disagreement?
Stability margin	Which boundaries and leading indicators reliably precede loss of stability?
Frame transformation	How should actant, team, enterprise and sovereign Grid frames translate?

Working definition

The Gudiya Cognitive Coordinate System is a federated, time-aware reference framework through which an actant, transient team or larger collective can estimate its identity, relational position, motion, uncertainty and stability condition within the observable Cognitive Field.

This definition describes the required function without claiming that the field is Euclidean, continuous or reducible to a small fixed set of orthogonal axes. CCS may ultimately combine graphs, tensors, state vectors, event histories and topological regions. The correct representation should be selected by predictive and operational performance, not by the elegance of a metaphor.

What CCS is not

- It is not a claim that cognitive space is identical to physical space.
- It is not a universal embedding produced by one foundation model.
- It is not a dashboard assembled only after an incident.
- It is not a central planner that assigns every action.
- It is not a replacement for cybersecurity, model alignment or domain control systems.
- It is not yet a finalized coordinate standard.

Candidate coordinate families

The original GCCS state vector named identity, timestamp, epoch, phase, intent, gain, latency, drift, stability, coupling, confidence and persistence. These remain useful candidates. Version 2 groups them by engineering purpose and adds authority, lineage, observation age, density and coordination burden.

Family	Candidate observables	Orientation question
Identity and lineage	ACS, KYA identity, model and harness lineage, delegated ancestry	Which continuing actant or authorized descendant is this?
Time and phase	Epoch, phase, observation age, update rate, prediction horizon	When is this estimate valid and how synchronized are the participants?
Intent and direction	Declared objective, inferred objective, objective divergence, destination state	What trajectory is the actant pursuing?
Authority and envelope	Permissions, resource access, approved intent group, operating boundaries	What motion is permitted in the present frame?
Velocity and load	Decision rate, tool action rate, information throughput, cognitive load	How rapidly is state changing relative to the field and team?
Coupling and proximity	Explicit links, implicit dependencies, rendezvous frequency, team membership	Which actants can affect one another now?
Gain and influence	Downstream amplification, propagation reach, sensitivity, reversibility	How much system change can one actant produce?
Persistence and memory	State age, unresolved commitments, recursive depth, stored objectives	What prior state continues to shape future behavior?
Stability and uncertainty	Margin, drift rate, oscillation, anomaly level, estimate confidence	How close is the actant or collective to an unsafe regime?

Position is relational

An actant does not possess one meaningful cognitive coordinate independent of context. Its location depends on the selected frame, nearby actants, active objectives, shared resources and current time. CCS therefore requires relational coordinates and transformations between frames. A low-risk actant in isolation may occupy a high-risk position after entering a dense, high-gain transient team.

Direction may matter more than location

The objective vector remains one of the strongest ideas from the August chapter. Two actants can occupy similar states while moving toward different outcomes. Conversely, actants with different internal implementations may share a stable collective direction. CCS must estimate trajectory and rate of change, rather than report static state alone.

Persistent architecture and transient team membership

System of Systems architecture describes relatively persistent ownership, interfaces and governance. AI teamwork describes operational collectives that form and dissolve as actants encounter one another. Both frameworks are needed because stable architecture does not imply stable real-time interaction.

Consider one thousand aircraft belonging to ten airlines, using fifty airports and crossing twenty five air traffic control sectors. Airlines, aircraft registries, airports and control sectors can be governed as

enduring systems. The seventeen flights departing Los Angeles during one thirty-minute interval form a different engineering object. Their operational membership is temporary, their relative motion changes continuously, and each flight later enters a new sector and a new team.

Persistent System of Systems view	Transient AI Teamwork view
Airline ownership and fleet identity	Flights currently sharing separation and sequencing constraints
Airport and ATC sector architecture	Actants entering and leaving a control relationship
Certified interfaces and standing governance	Real-time coupling, density, phase and coordination burden
Relatively stable membership	Dynamic, overlapping and sometimes momentary membership
Architecture assurance	Collective trajectory and stability management

Why CCS becomes necessary

A transient team needs a shared operational frame even when its members have different owners, models, clocks and internal representations. CCS supplies continuity while team membership changes. It can locate an actant relative to the present collective, translate that local estimate into the wider Grid frame and preserve the history after the team dissolves.

CCA and MMA hybrid fleets

The same distinction applies to collaborative combat aircraft and massed modular aircraft. Platform architecture, mission systems and command relationships belong to the System of Systems view. Machine-speed formations, changing escort relationships, payload-dependent couplings and degraded-communications regrouping belong to the transient-team view. CCS would allow each actant and supervisory element to estimate its field-relative condition as the hybrid fleet forms, separates and reforms.

Actant Cognitive Signature and Cognitive Cartography

MagNav matches a local magnetic signature against a maintained map. The cognitive analogue begins with the Actant Cognitive Signature, or ACS. An ACS is not the coordinate itself. It is the observable pattern from which the Grid can estimate identity, lineage, current behavior and local relationships.

Element	Function
ACS observation	Provides locally observable evidence about the actant and its current execution.
Field telemetry	Captures relevant environmental state, other actants and shared resources.
Cognitive map	Maintains reference landmarks, boundaries, typical trajectories and known regimes.
Estimator	Compares predicted state with observations and calculates a corrected position.
Uncertainty model	Records confidence, staleness, missing observations and disagreement.
Stability service	Uses position and trajectory to select monitoring, guidance or intervention.

Cognitive Cartography

Cognitive Cartography is the proposed discipline for discovering, mapping and maintaining reference features within the Cognitive Field. Candidate landmarks include approved intent boundaries, authority transitions, recurring rendezvous patterns, stable operating regions, known resonance zones, critical shared resources, centers of stability and centers of propagation.

The map must be versioned because the cognitive environment changes. A landmark that was reliable last week may lose meaning after a model update, a new agent protocol or a change in market behavior. Every position fix must therefore identify the map version, observation time and confidence interval used to calculate it.

Reference diversity

A single reference source can fail, drift or be manipulated. CCS should combine diverse evidence from Grid telemetry, enterprise controls, domain sensors, independent observers and historical trajectories. Agreement among independent references strengthens the fix. Disagreement is itself a coordinate-relevant anomaly.

The Grid must observe at the required rate

A coordinate estimate can alias rapid motion when the observation rate is too low. The required sampling rate is coupling-specific: a slow administrative workflow and a machine-speed trading loop cannot share one universal interval. CCS must carry observation cadence and temporal uncertainty so the Grid can distinguish genuine stability from undersampling.

The Grid as reference infrastructure

CCS does not require continuous central control. The Grid can publish standards, maintain maps, synchronize clocks and phases, reconcile observations, and issue corrective guidance while actants continue to make local decisions. This resembles instrument navigation more than remote piloting.

GUDIYA component	Contribution to CCS
KYA	Establishes authorized actant identity, ownership and initial operating context.
ACS	Supplies a continuing observable signature for identity and behavioral comparison.
GCR terminal	Carries information, cognition and telemetry through the sealed cognition veil.
UCGP	Provides a candidate epoch and phase reference across Grid participants.
Rendezvous Management	Observes and governs explicit and implicit couplings among actants.
GESR	Preserves stability history across migration, replacement and changing surfaces.
GRE	Estimates position, trajectory and stability margin and applies corrective action.
Federated Grids	Translate local coordinates while preserving sovereign and domain boundaries.

From VFR agents to IFR agents

A gridless actant resembles a pilot relying on local visual cues. It may operate safely while the environment is simple and legible. As density, speed and uncertainty increase, local perception becomes inadequate. A Grid-attached actant gains instruments that show field-relative attitude, trajectory and margin even when the actant cannot infer those conditions from its immediate context.

The Cognitive Attitude Indicator

The Cognitive Attitude Indicator is a CCS-derived instrument rather than a new coordinate axis. It summarizes whether an actant's apparent internal orientation agrees with the external Grid frame. A disagreement can identify cognitive disorientation before the actant crosses a hard boundary or produces an obvious failure.

Capability power and coupling

Capability describes what an actant can do. Power describes the authority and resources it has been given. Coupling describes the consequences that become possible when the powered actant interacts with other actants. CCS concentrates on this third dimension because individually authorized actions can still generate unstable collective motion.

Failure modes of a Cognitive Coordinate System

Creating CCS introduces its own hazards. The reference infrastructure must therefore be treated as a safety-critical engineered system and stabilized in its own right.

Failure mode	Consequence	Engineering response
Missing fix	The actant continues on an increasingly uncertain internal estimate.	Set maximum fix age by risk grade and coupling intensity.
Stale map	The actant is accurately located in an obsolete representation.	Version maps and expire landmarks when their validity changes.
Frame disagreement	Two correct measurements appear contradictory because they use different frames.	Carry frame identity and apply explicit transformations.
Spoofed reference	False observations induce a confident but incorrect correction.	Use reference diversity, provenance and cross-checking.
Observer effect	Measurement or intervention changes the collective being measured.	Model estimator influence and separate observation from control where possible.
Supervisory instability	Monitoring agents amplify noise or act in conflict.	Apply the Defend the Defenders principle to CCS services.
False precision	A convenient number conceals weak observability or an invalid model.	Publish uncertainty, model version and evidence quality with every fix.

The field is endogenous

Earth's magnetic field is largely unaffected by one aircraft. A Cognitive Field is different. Actants can alter objectives, workloads, prices, queues, information and other actants while being measured. CCS must therefore estimate motion in a field whose structure can change because of the participants themselves. This reflexivity is one reason a simple Cartesian analogy may prove inadequate.

Coordinate confidence is part of the coordinate

A cognitive location without uncertainty can be more dangerous than no estimate at all. Every CCS result should carry confidence, evidence freshness, observation coverage and model version. The Grid should distinguish unknown position from known instability and should reduce authority when orientation quality falls below the grade required for the mission.

A falsifiable SEI research program

CCS becomes a scientific theory only when its representations can be tested against observable outcomes. The research program should begin with bounded environments where interactions, timing and ground truth can be instrumented.

Research stage	Question	Evidence of progress
Operational vocabulary	Can identity, intent, authority, coupling, gain, persistence and uncertainty be defined consistently?	Independent teams label the same traces with acceptable agreement.
Coordinate candidates	Which variables improve prediction beyond ordinary logs and task state?	Candidate coordinates predict drift, overload or unstable coupling out of sample.
Reference landmarks	Which field features remain stable enough to correct local estimates?	Repeated fixes reduce position error across model and tool changes.
Frame transformations	Can actant, team and Grid views be translated without losing critical state?	Equivalent events yield consistent positions across organizational boundaries.
Sampling requirements	How frequently must each coupling be observed?	Experiments identify rates below which aliasing and missed instability rise sharply.
Intervention validity	Does a CCS-informed correction improve collective outcomes?	Controlled trials show fewer cascades or faster recovery without unacceptable loss of autonomy.
Generalization	Do the same principles transfer across enterprise agents, fleets, markets and supply chains?	A common core works across domains with bounded extensions.

Initial experiment

1. Construct a controlled multi-agent environment with persistent state, variable delay, recursive delegation and dynamic team membership.
2. Run the environment using only agent-local state and ordinary orchestration logs.
3. Introduce external field observations and calculate provisional CCS fixes with explicit uncertainty.
4. Compare drift detection, cascade prediction, intervention timing and recovery across the two conditions.
5. Repeat with changed models, observation rates and coupling structures to test whether the coordinates generalize.

What would weaken the theory

The CCS hypothesis would be weakened if external reference variables add no predictive or control value beyond existing local state, if proposed positions cannot be reproduced across observers, if frame transformations are arbitrary, or if corrective fixes fail to reduce bounded error. These are useful failure conditions because they prevent CCS from becoming an unfalsifiable metaphor.

Novelty and intellectual boundary

The ingredients of CCS have precedents. Robotics uses shared physical coordinate frames. Control theory uses state spaces and reference signals. Distributed systems use logical clocks and global-state approximations. Multi-agent AI uses shared memories, world models, coordination graphs and orchestration. The term cognitive coordinate system has also appeared in psychology to describe human spatial representation. [2]

The apparently fresh contribution is their synthesis into a persistent external framework for estimating the relational cognitive motion and stability of heterogeneous actants as they form, dissolve and reform teams. Recent multi-agent surveys organize coordination around perception, communication, decision, control, partner selection and coordination method. They do not establish an external, cross-domain CCS of the kind proposed here. [3] [4]

Current frontier work is moving toward the same problem neighborhood. Google has shown that agent architecture and task structure determine whether additional agents improve or degrade performance. Anthropic has warned that benign individual tendencies can compound into undesirable system-level outcomes at machine speed. Neither effort currently supplies the missing coordinate and orientation layer. [5] [6]

A defensible novelty statement

Existing research provides physical coordinate frames, state spaces, world models, coordination graphs and observability systems. GUDIYA extends these ideas into a proposed federated Cognitive Coordinate System for locating heterogeneous actants by their relative motion, coupling, uncertainty and stability condition. Its functional need is increasingly well supported, while its final structure remains to be discovered and tested.

The central propositions of Version 2

1. Internal state is not equivalent to systemic position.
2. Dynamic relative cognitive motion requires an external reference.
3. Every usable coordinate must identify its reference frame and time.
4. A field becomes navigable only through sensing, mapping and state estimation.
5. The ACS supplies evidence for a coordinate fix but is not itself the coordinate.
6. Persistent architecture and transient teamwork require different but coexisting frameworks.
7. CCS should guide local autonomy without becoming universal central command.
8. The coordinate structure must earn scientific legitimacy through measurement, prediction and intervention results.

Final conclusion

The August chapter asked whether cognition could be navigated. Version 2 supplies a more disciplined answer. Agentic systems are beginning to exhibit the conditions that make orientation infrastructure necessary: long-lived state, heterogeneous clocks, changing teams, implicit coupling, recursive delegation and machine-speed feedback. Internal intelligence cannot by itself provide an independent view of those relationships.

CCS is therefore functionally inevitable if society expects large populations of actants to operate together safely. The remaining work is substantial. Stability Engineering must discover what can be measured, which features remain reliable, how frames transform, how uncertainty grows and when an external fix changes an outcome. That unfinished geometry is no longer a weakness in the theory. It is the defined frontier of the research program.

CCS will be complete when an actant can answer not only what it is doing, but where it is moving in relation to the collective and how much stable maneuvering room remains.

References

- [1] Hanneke Weitering. Honeywell Tests Magnetic Navigation in GPS Free Flight. Aviation International News. 8 September 2026. [Source](#)
- [2] T Miwa and colleagues. Learning 4 D Spatial Representations Through Perceptual Experience With Hypercubes. IEEE Transactions on Cognitive and Developmental Systems. 2017. [Source](#)
- [3] Multi Agent Coordination across Diverse Applications A Survey. arXiv 2502.14743. [Source](#)
- [4] Multi Agent Systems From Classical Paradigms to Large Foundation Model Enabled Futures. arXiv 2604.18133. [Source](#)
- [5] Yubin Kim and Xin Liu. Towards a Science of Scaling Agent Systems. Google Research. 28 January 2026. [Source](#)
- [6] Anthropic Frontier Red Team. Patterns and Problems in Emerging Multiagent Systems. 13 August 2026. [Source](#)
- [7] Michal Pluhacek Simon Garnier and Andreagiovanni Reina. Decentralised Construction of a Global Coordinate System in a Large Swarm of Minimalistic Robots. arXiv 2302.14587. [Source](#)

Version history

Version 1 August 2026 Introduced GCCS, the UCGP reference, the state vector, objective vector and influence field concepts.

Version 2 September 2026 Recast CCS as a functionally necessary but structurally unfinished reference framework and incorporated the evidence and research developments summarized in this chapter.