Assimilation and Accommodation in the ALI Super-Ego: A Piagetian Model of Norm Development

ALI Simulation Series, Stage 8

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Abstract

We extend the adaptive Super-Ego of Stage 7 with a Piagetian norm development mechanism: assimilation handles perturbations that fit existing norms by adjusting weights; accommodation generates new norms from recurring norm-gaps that cannot be assimilated. Over 5000 training episodes, 10 accommodation events occur, all generating the same norm type (force-eat-search: block non-eating actions when energy is critical and no packet is underfoot). The central finding is a dynamic competition between accommodation and assimilation: the Ego's Q-learning independently closes the same norm-gap that the Super-Ego is accommodating, rendering the accommodated norms behaviorally redundant as learning progresses. The assimilation-accommodation boundary is not fixed but shifts with Ego learning maturity. By episode 5000, P1 norm-gap events have declined from 118 per interval to 12 total, survival reaches 96.6%, and base norm weights converge to their maximum (3.0) as in Stage 7. The accommodation mechanism produces structurally valid norms that respect the CC integrity condition, but their functional relevance decreases as the Ego's own learning achieves what the Super-Ego was normalising. This mirrors Piaget's observation that accommodated schemas can become redundant when more general assimilation schemas develop, and establishes a formal parallel between cognitive equilibration and normative equilibration in multi-instance ALI architectures.

1. Introduction

The ALI simulation series has progressively refined the Super-Ego from a static filter (Stages 1-6) to an adaptive weight-learning system (Stage 7) to a norm-generating architecture (Stage 8). The theoretical motivation for Stage 8 derives from the observation that both Stage 7 and the biological systems it draws on face a common problem: a fixed normative repertoire cannot cover situations that were not anticipated at design time. In Piaget's developmental theory, this problem is resolved through two complementary processes. Assimilation incorporates new experience into existing schemas without changing their structure. Accommodation modifies or generates new schemas when existing ones are insufficient to handle a perturbation.

The analogy to the ALI Super-Ego is precise and non-metaphorical. Assimilation in the Super-Ego corresponds to weight adaptation: the existing normative structure processes a perturbation by adjusting the relative emphasis of existing norms. Accommodation corresponds to norm generation: a recurring situation that no existing norm covers causes the Super-Ego to generate a new norm. The system-integrity condition — Piaget's equilibration — corresponds to the CC stability requirement: no accommodation that destabilises the causal core is accepted.

2. Architecture: The Piagetian Super-Ego

2.1 Perturbation Classes

Three perturbation classes are defined:

P1 (Norm-gap): The agent idles while the CC is under pressure and no existing norm applies. This is the primary accommodation trigger: a situation the normative architecture cannot handle.

P2 (Norm-conflict): Two norms are simultaneously activated with contradictory implications. Not implemented in the current stage but defined as an architectural slot for future extension.

P3 (Norm-ineffective): A norm is activated but the CC does not stabilise after compliance. The norm is doing the right thing structurally but achieving no functional benefit.

2.2 Assimilation (Identical to Stage 7)

The assimilation mechanism is unchanged from Stage 7: norm weights adapt based on activation frequency and CC stability. Norms that are never triggered grow in weight (sensitisation); norms triggered frequently under stable CC conditions soften. Meta-norms M1-M3 prevent collapse.

2.3 Accommodation: Norm Generation

When a P1 norm-gap state accumulates more than 15 occurrences within an adaptation interval, the Super-Ego attempts accommodation. The accommodation process analyses the problematic state and generates a candidate norm:

State (energy_critical, not_carrying): generates a force-eat-search norm that blocks non-eating actions when energy is critical and no energy packet is at the current position.

State (integrity_critical, any): generates a force-rest norm that blocks movement when integrity is critical and the agent is not at the station.

The CC integrity condition governs acceptance: a candidate norm is proposed only when the CC is not currently stable. If the CC is stable, no accommodation is needed regardless of norm-gap frequency.

Accepted norms join the active normative set and are applied in subsequent episodes alongside the base norms. New norms begin with a lower weight (0.8) than base norms (1.0), reflecting their provisional status.

3. Results

3.1 Accommodation Events

Over 5000 training episodes, 10 accommodation events occur. All 10 generate the same norm type: force-eat-search. The events are concentrated in the first 500 episodes (7 events), with 3 further events at episodes 1250, 3350, and 4450. No force-rest norms are generated because the integrity-critical state is not the dominant norm-gap pattern: the Q-learning Ego already manages integrity through proactive rest, as established in Stages 6 and 7.

The repetition of the same norm type is theoretically significant. It reveals that the accommodation mechanism correctly identifies a single recurring structural gap, not multiple unrelated problems. The system is not generating diverse norms arbitrarily; it is repeatedly recognising the same mismatch between its existing normative structure and a recurring environmental situation.

3.2 The Assimilation-Accommodation Competition

The most important finding of Stage 8 is the dynamic competition between accommodation and Q-learning. In episodes 1-500, P1 norm-gap events are frequent (up to 118 per interval), and 7 accommodation events occur. The accommodated norms are structurally correct: they prescribe eating-priority behavior when energy is critical. But simultaneously, the Q-learning Ego is learning the same behavior through its reward signal.

By episode 1000, the Ego has learned reliable survival (82.6%) and P1 events have dropped substantially. By episode 1500, base norm weights have reached their maximum (3.0) and P1 events are sporadic. The accommodated norms remain in the normative set but are rarely triggered because the Ego has independently learned to avoid the situations they address.

By episode 5000, total P1 gap events are 12, survival is 96.6%, and deliveries have increased to 0.09 per episode. The accommodation mechanism has become largely dormant because the Ego's learned behavior has closed the norm-gaps that triggered it.

3.3 The Dynamic Assimilation-Accommodation Boundary

The central theoretical finding is that the boundary between assimilation and accommodation is not a fixed property of the normative architecture but a function of Ego learning maturity. Early in training, when the Ego's Q-table is sparse and behavior is poorly adapted, norm-gaps are frequent and the accommodation mechanism is active. As the Ego matures, it closes gaps through learned behavior, reducing the need for accommodation.

This mirrors Piaget's account of cognitive development: accommodated schemas do not disappear when a more general assimilation schema develops, but they become functionally dormant. The Stage 8 Super-Ego retains its 10 accommodated norms at episode 5000, but they are applied rarely because the Ego's learned behavior makes the triggering conditions uncommon.

3.4 CC Integrity Condition: No Destabilising Accommodations

The CC integrity condition — only accommodate when the CC is not stable — is never violated. All 10 accommodation events occur during periods of CC instability in early training. No accommodation is proposed or accepted when the CC is stable. The system-integrity constraint is effective: it prevents the normative architecture from generating norms in response to irrelevant perturbations during periods of good function.

P3 (norm-ineffective) events are zero across all 5000 episodes. The norms that exist are doing what they are designed to do: when they fire, they move the system toward CC stability. The absence of P3 events suggests that the normative architecture, despite being partially redundant with the Ego's learned behavior, is internally consistent.

4. Discussion

4.1 Normative Equilibration

Piaget's concept of equilibration — the balance between assimilation and accommodation that characterises mature cognition — finds a precise formal analogue in the Stage 8 results. Equilibration in the ALI architecture is the state in which the Ego's learned behavior and the Super-Ego's normative structure are mutually consistent: the Ego rarely triggers norms because it has learned to respect them, and the Super-Ego rarely needs to accommodate because the Ego handles novel situations through its learned repertoire.

The Stage 8 system approaches but does not fully reach normative equilibration by episode 5000: P1 events continue at a low rate, and new accommodations occur sporadically. Full equilibration would require either a longer training horizon or a richer environmental complexity that drives the Ego to explore more of the state space.

4.2 The Redundancy Problem

The 10 accommodated norms are structurally valid but functionally redundant by the end of training. This raises a design question for real deployments: should the normative architecture prune redundant accommodated norms, or retain them as latent safety backstops? The Stage 7 finding — that latent norms that are never triggered are strengthened by the growth rule — applies here too. Retaining redundant accommodated norms may be preferable for deployment resilience: if the Ego's learned behavior degrades (due to distribution shift, hardware failure, or novel environments), the accommodated norms provide a safety net that hardcoded base norms alone might not cover.

4.3 Toward Real-World Deployment

Stage 8 completes the simulation series' exploration of the normative learning space. The eight stages have demonstrated: basic three-instance architecture (Stages 1-2), multi-agent dynamics (Stage 3), Q-learning Ego (Stage 4), multi-dimensional CC (Stage 5), strategic inversion under learning (Stage 6), norm sensitisation under adaptive weights (Stage 7), and Piagetian norm generation with dynamic assimilation-accommodation boundary (Stage 8).

The transition to Stage 9 — real-world deployment in a domain-specific prototype — can now proceed with a normative architecture that is: statically grounded in the CC, adaptively weighted through use, capable of generating new norms from recurring norm-gaps, and protected by the CC integrity condition against destabilising accommodation. This architecture addresses the concern raised in the Stage 7 paper that adaptive normative systems may erode under learning: the evidence from Stages 7 and 8 is that they consolidate and extend rather than erode.

5. Conclusion

Stage 8 introduces a Piagetian norm development mechanism into the ALI Super-Ego. Assimilation handles perturbations through weight adaptation; accommodation generates new norms from recurring norm-gaps subject to the CC integrity condition. Over 5000 episodes, 10 accommodation events occur, all targeting the same structural gap. The central finding is a dynamic competition between accommodation and Q-learning: as the Ego matures, it closes norm-gaps through learned behavior, rendering accommodated norms functionally dormant while they remain as latent safety backstops.

The assimilation-accommodation boundary shifts with Ego learning maturity, providing a formal parallel to Piaget's account of cognitive equilibration. The Stage 8 architecture completes the simulation series and establishes a normative learning framework suitable for the transition to domain-specific real-world deployment.

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