Recursive Risk Awareness:

The Emergence of an Autopoietic Risk-System through Long-Term Structural Coupling in High-Risk Physical Performance

Rekursive Risikowahrnehmung: Die Emergenz eines autopoietischen Risikosystems durch langfristige strukturelle Kopplung in physischen Hochrisikodisziplinen

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Abstract

This paper introduces the concept of Recursive Risk Awareness as an autopoietic system that emerges through long-term structural coupling between a licensed Artistik-Coach and high-risk performers. Drawing on second-order cybernetics (von Foerster, 1974; Maturana & Varela, 1987), we argue that after more than 11 years of intensive embodied practice, risk perception transcends individual cognition and becomes a self-referential, self-maintaining property of the coupled coach-athlete system.

Based on extensive practice-based research as a performing acrobat, stilts artist, and licensed Artistik-Coach, three developmental phases are identified: (1) external first-order coaching, (2) structural coupling, and (3) the emergence of an operationally closed autopoietic risk-system. In the final phase, risk decisions arise faster and more accurately from the system itself rather than from conscious individual analysis.

The practical benefits are substantial: significantly reduced injury rates, accelerated skill acquisition, enhanced performance under pressure, and improved adaptability in unpredictable live environments. These findings have direct implications for coach education, injury prevention, and performance optimization in circus, aerial arts, team sports, special forces training, and other high-risk domains.

Theoretically, this study extends autopoiesis and second-order cybernetics into the realm of embodied high-risk performance — a field that has received little systematic attention. It demonstrates that profound systemic intelligence can emerge directly from artistic and bodily practice, offering a new paradigm for understanding risk, learning, and human-system interaction.

Keywords: *recursive risk awareness, second-order cybernetics, autopoiesis, structural coupling, embodied cognition, high-risk performance, Artistik-Coaching, injury prevention*

1. Introduction

[English]

Risk in high-performance physical disciplines has predominantly been studied from a first-order perspective: an external observer measures, categorizes, and attempts to predict risk events as if they were objective phenomena separable from the observing subject (Kahneman, 2011; Slovic, 1987). In sport science, this manifests in biomechanical risk assessments, injury statistics, and protocol-driven coaching frameworks that treat the athlete as a discrete, bounded system and the coach as an external regulator of that system (Bahr & Krosshaug, 2005). While such approaches yield valuable epidemiological data, they systematically exclude a dimension of risk that becomes increasingly salient in long-term, high-risk physical performance: the risk awareness that emerges from the relationship between coach and performer, rather than residing within either one alone.

This paper proposes a fundamentally different conceptual framework. Drawing on second-order cybernetics (von Foerster, 1974; Umpleby, 2016) and autopoietic systems theory (Maturana & Varela, 1980, 1992), we argue that extended co-practice between a coach and performing artist can give rise to a self-referential, self-maintaining risk-system — one that operates at the level of the dyad rather than the individual. We term this emergent phenomenon Recursive Risk Awareness (RRA): a form of distributed, embodied risk cognition that is jointly constituted, recursively maintained, and operationally closed to its environment in the sense that Luhmann (1995) describes for social systems.

The empirical basis is grounded in over eleven years of professional practice as a performing acrobat, stilts artist, and licensed Artistik-Coach — including solo high-wire performance, partner acrobatics in the sustained Yin & Yang duo collaboration with the author's brother Jim, and live ensemble performance in professional circus and theater contexts. The central research question: How does long-term structural coupling between a coach and a performing artist generate a recursive, autopoietic risk-awareness system that transcends individual cognitive capacity?

[Deutsch]

Risiko in physischen Hochleistungsdisziplinen wurde bislang überwiegend aus einer Perspektive erster Ordnung untersucht. Dieser Beitrag schlägt ein grundlegend anderes konzeptuelles Rahmenwerk vor: Aufbauend auf der Kybernetik zweiter Ordnung und der Theorie autopoietischer Systeme wird argumentiert, dass intensive Ko-Praxis zur Entstehung eines selbstreferentiellen Risikosystems auf Dyadenebene führen kann — der Rekursiven Risikowahrnehmung (RRA).

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2. Literature Review

[English]

Research on risk perception in high-performance contexts has been dominated by two principal approaches. The first, rooted in cognitive sport psychology, treats risk awareness primarily as an individual skill involving situational awareness, decision-making under pressure, and mental models (Raab & Araújo, 2019; Ward et al., 2022). While these studies have produced important insights, they remain largely first-order: the coach or researcher is positioned as an external observer analysing the athlete's cognition.

A second line of inquiry has shifted the focus to interpersonal processes, particularly shared mental models (SMM) and team cognition in high-risk environments. Studies in circus acrobatics (Filho et al., 2018) and other team-based high-stakes domains (Eldadi et al., 2025) demonstrate that long-term collaboration leads to implicit coordination and improved safety outcomes. Similarly, research on coach-athlete relationships has shown that relational quality significantly influences injury rates and performance development (Kuhlin et al., 2020; Tranaeus et al., 2024).

More recently, the field of embodied cognition has begun to challenge purely representational models, arguing that risk perception is distributed across the body-environment system (Cappuccio, 2019; Raab & Araújo, 2019). In dance and contact improvisation, analogous phenomena have been identified: autopoietic processes between

dancers and choreographers (Bishop, 2017), embodied metacognition in expert performers (Yang et al., 2023, 2024), dyadic coordination in partner dance (Hartmann et al., 2019), and collective sense-making through improvisation (Nelson et al., 2024).

Nevertheless, a critical theoretical gap remains. Existing literature rarely applies second-order cybernetics (von Foerster, 1974) or autopoiesis theory (Maturana & Varela, 1987) to embodied high-risk performance. Consequently, the transformation of risk awareness into a self-referential, operationally closed autopoietic system has not been systematically described. The present study addresses this lacuna.

[Deutsch]

Trotz wachsender Evidenz zu Shared Mental Models (Filho et al., 2018; Eldadi et al., 2025), Coach-Athlet-Beziehungen (Kuhlin et al., 2020) und verkörperter Kognition (Cappuccio, 2019) fehlt ein kohärenter Rahmen, der erklärt, wie strukturelle Kopplung Risikowahrnehmung in ein operational geschlossenes autopoietisches System transformiert. Diese Studie schließt diese Lücke.

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3. Theoretical Foundation

[English]

3.1 Second-Order Cybernetics: The Observer as Part of the System

Classical cybernetics concerned itself with self-regulating systems and feedback loops (Wiener, 1948; Ashby, 1956). The observer stands outside the system. Von Foerster (1974) radically challenged this assumption in second-order cybernetics: any rigorous account of a system must include the observer as a constitutive component. To observe a system is to participate in its construction. This position aligns with constructivist epistemology (von Glasersfeld, 1995) and mature systems thinking (Luhmann, 1995; Umpleby, 2016). Applied to coaching: the coach is not an external regulator but a

constitutive part of the observing system, progressively integrating with the athlete into a shared self-observing whole.

3.2 Autopoiesis and Structural Coupling: Maturana and Varela

Autopoiesis (Maturana & Varela, 1980) describes living systems that continuously produce and maintain their own constitutive components — self-generating, self-bounding, operationally closed networks. Operational closure does not entail causal isolation: structural coupling allows recurrent interactions through which system and environment mutually modify each other's structural conditions. Third-order coupling — the coupling of two autopoietic systems with one another — generates a new coupled system whose organizational properties cannot be reduced to either component individually. This is the generative mechanism of Recursive Risk Awareness.

3.3 Embodied Cognition and Risk Perception in High-Stakes Environments

The embodied cognition paradigm (Varela, Thompson & Rosch, 1991; Gallagher, 2005; Noë, 2004) holds that cognition is constituted through sensorimotor engagement with the environment: perception is action. In extreme physical performance, the sequential model of risk perception (sense → process → respond) is inadequate: timescales are too compressed for deliberate cognitive processing. Effective risk response is pre-reflective, organized through body schema and proprioceptive attunement (Dreyfus, 2002; Sheets-Johnstone, 2011). In the deeply coupled coach-athlete system, the body schema of each participant extends to incorporate the other — consistent with Clark and Chalmers' (1998) extended mind thesis. Risk is sensed through a shared somatic field spanning both bodies simultaneously.

[Deutsch]

Das theoretische Fundament verbindet drei Traditionen: Kybernetik zweiter Ordnung (Beobachter als Systemkomponente), Autopoiese und strukturelle Kopplung dritter Ordnung (Emergenz eines nicht-reduzierbaren Dyaden-Systems) sowie verkörperte

Kognition (Erweiterung des Körperschemas auf den gekoppelten Partner). Gemeinsam liefern sie einen Rahmen, in dem Risikowahrnehmung nicht als innerer mentaler Zustand, sondern als Prozess des gekoppelten Ganzen verstanden wird.

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4. Methodology: Practice as Research

[English]

This study employs a practice-based research methodology (Nelson, 2013; Smith & Dean, 2009) combined with long-term autoethnography and second-order cybernetic inquiry. The researcher — John Förster (BERLINJOHN), B.A. Medien-Wirtschaftspsychologie, licensed systemic coach and state-accredited Artistik-Coach — is not an external observer but an active, constitutive participant in the very system being studied.

4.1 Research Positionality

The author has worked professionally as a licensed Artistik-Coach, performing acrobat, and stilts artist since 2010. He holds a B.A. in Medien-Wirtschaftspsychologie and certifications in systemic coaching. His performance career includes appearances on Das Supertalent, America's Got Talent, and Ninja Warrior, as well as Guinness World Records achievements. The core data source is the continuous 11-year structural coupling with various athletes, with particular depth in the Yin & Yang Duo collaboration with his brother Jim since 2015. This positionality is the central condition of possibility for the study: only through deep personal involvement could the recursive dynamics become observable.

4.2 Data Collection (2014–2026)

Data were collected systematically across five modalities:

- **Training Documentation:** Over 1,200 detailed training protocols including perceived risk levels (1–10 scale), emotional states, and observed systemic reactions.
- **Video Corpus:** More than 450 hours of recorded material from training sessions, rehearsals, and live performances, with slow-motion analysis of critical moments.
- **Reflexive Field Notes:** Written within 30 minutes after each significant session in second-order format: "What did the system do?" rather than only "What did I do?"
- **Physiological Coupling Records:** Consistent documentation of breathing synchronization, muscle tone feedback, and non-verbal micro-cues during high-risk elements.
- **Critical Incident Reports:** In-depth reconstruction of 47 significant risk events, including 9 minor injuries and 38 near-miss situations.

4.3 Analytical Process

1. Phase Mapping — Chronological ordering to identify the three developmental phases.
2. Recursive Second-Order Analysis — Each incident examined from both first-person ("What did I perceive?") and system perspectives ("How did the coupled system self-correct?").
3. Theoretical Triangulation — Continuous comparison with von Foerster, Maturana & Varela, embodied cognition, and high-reliability organizations research.

4.4 Validity Measures

- Prolonged Engagement: 11+ years of continuous practice.
- Member Checking: Regular validation with brother Jim (Yin & Yang Duo).
- Peer Debriefing: Discussion with experienced coaches and performers outside the immediate system.

- Thick Description: Detailed situational contextualization to enable transferability assessment.
- Reflexivity Audit: Ongoing documentation of the researcher's influence on the observed system.
- Negative Case Analysis: Explicit documentation of situations where the autopoietic risk-system did not function.

[Deutsch]

Praxisbasierte Forschungsmethodik (Nelson, 2013; Smith & Dean, 2009) kombiniert mit Autoethnografie und kybernetischer Reflexivität zweiter Ordnung. Forscher: John Förster (BERLINJOHN), B.A. Medien-Wirtschaftspsychologie, lizenzierter systemischer Coach, staatl. anerkannter Artistik-Coach. Datenbasis 2014–2026: 1.200+ Protokolle, 450h Video, 47 Critical-Incident-Reports. Analyse: Phasenmapping, Zweite-Ordnung-Analyse, theoretische Triangulation. Validität: Member Checking mit Jim, Peer Debriefing, Negative Case Analysis.

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5. Findings: The Emergence of Recursive Risk Awareness

[English]

5.1 Phase 1: External Coaching and First-Order Observation (Years 1–3)

The coach-athlete relationship conformed to a first-order model: the coach as external observer issuing technical corrections and verbal risk assessments. Risk decisions were mediated through conscious cognitive processing. No recursive loop between coach and athlete had yet formed. Concrete example: stilt pyramid training with elevated center of gravity — despite sound verbal instruction, falls and minor injuries occurred frequently because athletes lacked an internalized somatic risk-feeling. The system was reactive rather than anticipatory.

5.2 Phase 2: Structural Coupling — The Coach Enters the Perceptual Field (Years 3–7)

Through continuous physical, sensory, and emotional coupling — shared training, mutual spotting under real load conditions, co-presence in live performance situations — the coach became an integral component of the athlete's perceptual field. Consistent with Maturana and Varela's (1980) structural coupling, the coach's body, breath, and postural micro-variations became part of the athlete's sensorimotor reference system. Concrete example: In Yin & Yang stilt work with Jim, a minimal weight shift by one partner caused the other to instinctively compensate the balance of the entire system, without looking. Training injuries declined significantly despite increased technical demands.

5.3 Phase 3: The Autopoietic Risk System — Decisions Emerging from the System (Years 7–11+)

The coupled system entered operational closure. Risk decisions emerged from the system as a whole — faster and more accurately than individual analysis could produce. Paradigmatic example 1: During a live Berlin-Mitte performance, a high-risk stilts pyramid corrected itself through microscopic weight redistributions without a single word being spoken. Paradigmatic example 2: In a demanding Yin & Yang lift, a single barely perceptible breath from the lower partner (John) caused Jim to abort a rotation and roll safely away — before any conscious risk impulse had formed. The recursive structure knew — not the coach, not the athlete.

Empirical indicators: marked injury rate reduction despite increasing technical complexity; abbreviated learning curves for new high-risk elements; coordinated risk decisions under acute adrenergic arousal (Sapolsky, 2004). This is not skilled teamwork in the conventional sense (Polanyi, 1966). It is a system in which risk awareness is no longer an attribute of persons, but a process of the coupled whole.

[Deutsch]

Phase 1 (Jahre 1–3): Coaching erster Ordnung, verbale Instruktion, externe Risikobewertung — Verletzungen häufig. Phase 2 (Jahre 3–7): strukturelle Kopplung — minimale Gewichtsverschiebungen von Jim lösen instinktive Systemkompensation aus; Verletzungsrate sinkt signifikant. Phase 3 (ab Jahr 7): operational geschlossenes autopoietisches System — die Berliner Stelzenpyramide korrigiert sich wortlos; ein kaum wahrnehmbarer Atemzug löst sicheres Abrollen aus. Das rekursive Gefüge weiß — nicht der Coach, nicht der Athlet.

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6. Discussion

[English]

6.1 Theoretical Contribution

The concept of Recursive Risk Awareness (RRA) as an autopoietic system extends second-order cybernetics (von Foerster, 1974; Umpleby, 2016) and autopoietic theory (Maturana & Varela, 1980, 1992) into embodied high-stakes physical performance. Previous research has examined shared mental models (Filho et al., 2018; Eldadi et al., 2025) and embodied cognition (Raab & Araújo, 2019; Cappuccio, 2019) in high-risk performance, but these approaches remain first-order and descriptive. RRA extends the distributed cognition framework (Hutchins, 1995) and the extended mind thesis (Clark & Chalmers, 1998) by adding a dynamic, developmental dimension: through years of recurrent interaction, the boundaries of each participant's sensorimotor system are literally redrawn to incorporate the other — constituting a new autopoietic system at the level of the dyad.

6.2 Practical Implications

Coach education: long-term structural coupling should be recognized as a core professional competence in high-risk disciplines. Injury prevention: the Phase 3 evidence points toward an anticipatory risk-system that detects and corrects perturbations at a speed deliberate cognitive monitoring cannot match. Performance optimization: dyads achieving

autopoietic integration exhibit qualitatively superior adaptive capacities under uncertainty. Applications extend to circus, aerial arts, surgical teams (Catchpole et al., 2008), aviation crew resource management (Helmreich, 2000), and military special operations (Klein, 1999).

6.3 Limitations

As a practice-based, autoethnographic investigation, findings are unavoidably perspectival and context-specific (Berlin street and stage performance, European new circus tradition). Generalizability requires independent empirical investigation. The three-phase model is a retrospective reconstruction; the absence of prospective physiological data limits causal claims. The paper makes a theoretical argument grounded in longitudinal practitioner experience, not strong nomothetic claims.

6.4 Future Research Directions

A systematic research agenda should pursue: (1) replication studies across domains to determine whether the three-phase model is universally identifiable; (2) indicator development — physiological synchrony measures (HRV coupling, respiratory entrainment, correlated EMG activation), eye-tracking coordination, decision-latency comparisons; (3) intervention studies investigating whether autopoietic closure can be intentionally accelerated and whether acceleration carries costs in system robustness.

[Deutsch]

RRA als autopoietisches System erweitert bestehende Ansätze zu Shared Mental Models und verkörperter Kognition um eine dynamische, entwicklungsbezogene Dimension: Durch jahrelange Interaktion werden die Grenzen des sensomotorischen Systems jedes Beteiligten neu gezogen — ein neues autopoietisches System auf Dyadenebene entsteht. Praktische Implikationen: Coach-Ausbildung (strukturelle Kopplung als Kernkompetenz), Verletzungsprävention (antizipatorische Systeme), Leistungsoptimierung, und Transfer auf Chirurgie, Militär, Luftfahrt.

7. Conclusion

[English]

This paper has argued that long-term structural coupling between a coach and performing artists in high-risk disciplines can give rise to a genuinely autopoietic risk-system: a self-referential, self-maintaining form of distributed intelligence that cannot be reduced to the cognitive capacities of either individual participant. Three developmental phases — first-order observation, structural coupling, autopoietic closure — were identified across eleven years of professional practice, with the Yin & Yang collaboration providing the most phenomenologically precise illustration of Phase 3 dynamics.

Three interconnected contributions: First, this paper extends autopoietic theory and second-order cybernetics into high-risk physical performance — a domain cybernetic scholars have not systematically addressed. Second, it provides a rigorous theoretical language for phenomena practitioners have long observed intuitively: collective risk anticipation, the "system deciding" before any individual has consciously registered a danger. Third, it demonstrates that rigorous theoretical insight can emerge directly from sustained artistic and bodily practice — not despite its subjective, first-person character, but through it.

The practical implications extend well beyond the performing arts. Coach education, injury prevention, performance optimization, and risk management across high-stakes domains can be fundamentally reconsidered when risk awareness is understood not as an individual cognitive competence but as a systemic, living property of coupled human practice. The recursive risk-system described in this paper is not a metaphor. It is a living reality that has been practiced, inhabited, observed, and — here, for the first time — rigorously named.

[Deutsch]

Drei Entwicklungsphasen — Beobachtung erster Ordnung, strukturelle Kopplung, autopoietische Geschlossenheit — wurden über elf Jahre professioneller Praxis identifiziert. Drei Beiträge: Erweiterung von Autopoiese und Kybernetik zweiter Ordnung auf hochriskante Performanz; theoretische Präzisierung intuitiv bekannter Praktiker-Phänomene; Nachweis, dass rigorose theoretische Einsicht aus verkörperter Praxis entstehen kann. Das rekursive Risikosystem ist keine Metapher. Es ist eine gelebte Realität — praktiziert, bewohnt, beobachtet und hier, zum ersten Mal, präzise benannt.

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