Task Ambiguity in Combat Shooting Environments: Training Implications of an Ecological Dynamics Perspective

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Abstract

Traditional military combat shooting training is typically static, highly structured, and planned. It often uses single-target engagements, lacking the requirement for friend and foe discrimination and fails to include the ambiguity and uncertainty of tasks found in real-world combat environments. This means that training may not successfully simulate combat challenges to survival and navigation of military environments. Here, we discuss an ecological dynamics approach to provide an alternative view of traditional military combat shooting training doctrine. We outline why this alternative view is advantageous for rethinking combat shooting training to prepare combatants for the uncertainties of the military environment. The paper introduces the concept of 'task ambiguity' and its constituent components: fields of affordances, action uncertainty, and changing informational constraints. We provide examples throughout from military and sporting contexts of how task ambiguity shapes perception, action, and cognition of performers. Last, we discuss practical implications for the training of combat shooters to create enskilled, adaptable combatants who can successfully navigate uncertain and ambiguous surroundings.

Keywords: Ecological Dynamics, Coaching, Skill Acquisition, Combat Shooting, Military Environments

Highlights

- Task ambiguity refers to an individual's attunement to dynamic performance contexts. Greater attunement to task and environmental constraints, leads to less uncertainty in finding one's way to achieve an intended task goal.
- Within the ecological dynamics framework, task ambiguity increases as the information increases in a performance context.
- Task ambiguity can shape the representative design of training, simulating combat environments.
- Task ambiguity is necessary to improve skill transfer, facilitating adaptive performance behaviours.

Introduction to Combat Shooting

Combative military environments are dangerous, full of ambiguous information and life-threatening features, generating considerable uncertainty for combatants. Modern military conflicts have ill-defined battle zones, especially within urban areas full of civilians (Clemente-Suárez & Robles-Pérez, 2013). Increasing a combat shooter's survivability is paramount, considering the high threat to life. Busa et al. (2015) highlighted three sub-components of survivability using the lens of ecological psychology: situational awareness, mobility and lethality. Situational awareness is essential to perceive, identify, and distinguish information on threats (e.g., number of targets, friend or foe, locations). Mobility is a combat shooter's capability to identify targets and protective cover efficiently (Busa et al., 2015; Villa et al., 2019). Lethality is a combat shooter's ability to neutralise a threat (i.e., shooting proficiently; (Lawson et al., 2016).

Combat shooting is enacted at various distances and can involve attacking and defensive interactions between opposing groups. Combat shooters perform under distinct task constraints. These include dynamic conditions (with both combat shooter and target in motion), limited time to act, unplanned engagement (at undefined target locations), multi-target engagements, possibly requiring friend-or-foe discrimination (Bale et al., 2024). These features of combat environments are rarely actualised in training and testing design (Bale et al., 2024). For example, typical shooting proficiency tests are highly structured and documented, following pre-defined rigid requirements in isolated tasks (Biggs et al., 2023). This is a challenge because combative military environments can be unstructured, dynamic and require attention to multiple simultaneous tasks (Bale et al., 2024; Clemente-Suárez & Robles-Pérez, 2013; Jensen et al., 2023).

The survivability of combat shooters is of utmost importance, and increasing it is vital. There is a need to understand how to enhance the representative design (realistic simulation; (Brunswik, 1956; Pinder et al., 2011) of combat shooting training to improve situational awareness, mobility and lethality. To improve the representative design of methodologies, there is a need to implement requirements for decision-making, perceptual search activities and problem-solving to improve combatant survivability. The inclusion of problem-solving requires more variable and unstructured environments, with trainees facing multiple tasks simultaneously.

The Ecological Dynamics perspective on perception and action

Representative practice design aids trainers and instructors in understanding how performers interact with key information sources in their environment (Pinder et al., 2011). It advocates the integration of perception and action at the performer-environment scale to facilitate functional performance behaviours(Araújo et al., 2006). A central concept in ecological dynamics is *affordances* (opportunities for action) that shape how performers interact with information within their environments (Gibson, 1979).

Information is everywhere within performance environments. To wayfind through uncertain environments, humans have evolved to perceive surrounding information through different perceptual systems to regulate their actions (Gibson, 1966; Turvey, 1986). Wayfinding is "a narrative way of moving through a landscape" (Woods et al., 2021, p. 7). Wayfinding is not directly concerned with navigating from position A to position B, but is concerned with the journey itself, especially with an individual's transactional[1] relations with

[1] 'Transactional' - referring to how goal-directed behaviour emerges from the dynamically differing relationship imposed between the constraints of the task environment and the capacities of a performer.

the surrounding environment. Gibson (1979) postulated that energy sources, like light and sound waves, are reflected from features of the environment, revealing its informational structure. Available energy forms an ambient array (distribution/structure), rich with spatial-temporal information that allows a performer to perceive environmental properties, structured layout, and events directly and unambiguously. The unambiguity of information allows it to directly *specify* meaning to a performer (Gibson, 1979). Further, information within the environment is continuous, structured, invariant, and highly complex, requiring no mental processing for further embellishment (Williams et al., 1999). Instead, humans directly perceive invariant properties of the environment, available as *affordances* (opportunities or possibilities to act)(Gibson, 1979).

Gibson (1979, p. 127) proposed that "the affordances of the environment are what it offers the animal, what it provides or furnishes, either for *good or ill.*" Gibson's words exemplify the task ambiguity in combat environments where many features, objects and others within the affordance landscape may threaten survivability or provide support. The same affordances can provide support for one individual but may harm another occupying the performance environment. In a combat context, a wall could afford protective cover for a shooter or hide an enemy, a target could afford shooting or need protecting, and a hand-held object may be a weapon or a gift.

Affordances are simultaneously objective (i.e., phenomenal) and subjective (i.e., they invite a particular action from a specific performer) (Fitch & Turvey, 1978; Warren, 1984). An affordance is subjective due to the effectivities (capacities, dispositions, tendencies) and intentionality (i.e., to maintain survival whilst searching a house or military zone) of each individual within the affordance landscape (Turvey, 1992). The objective nature of affordances is their unwavering availability within the environment, whether realised by every performer, depending on each individual's effectivities and specific attention (Turvey,

1992; Withagen et al., 2017). A wall that is only waist high would not afford sufficient cover if standing; rather, combat shooters would have to adapt their movements (kneel, squat, crouch or lie flat) in their transactions with that affordance. Therefore, an affordance is a direct link between a performer and their environment, specifying how one must interact with these environmental properties to meet intended task goals. These prominent ideas in James Gibson's (1979) theory of direct perception advocate analysis of the performer-environment relationship when evaluating human performance behaviours involving perception, action and cognition (Araújo et al., 2006).

Information constrains actions, and vice versa, and the affordances we utilise (Passos et al., 2008), enabling the emergence of coordinated actions (Davids et al., 2008). In ecological dynamics constraints are categorised into task, individual, and environment features (Newell, 1986). Task constraints are specific to performance demands, including locations, technologies, spaces, equipment, rules and boundaries (Handford et al., 1997). Individual constraints are those specific to every performer, like differing intentions, hand-eye coordination, mass, height, strength, emotional states, fatigue or previous experiences with a task (Renshaw & Chow, 2019). Environmental constraints include the physical properties of our surroundings (e.g., combat context, weather, temperature, ambient light, altitude) or the social context in which a performer operates (e.g., beliefs, cultural norms, history).

Constraints can shape what a performer perceives as an affordance if they are attuned to surrounding information, For example, if fatigued, combat shooters can adapt actions to stop pursuing a target and instead engage targets at greater distances, aiming at targets for longer periods. Thus, a change in individual constraints may change affordances to shoot at a target and performance behaviours (Nibbeling et al., 2013).

Though information itself is unambiguous (Gibson, 1979), when the information sources in a combat environment are *nested* together, the dynamic nature of a *field of affordances* can shape *task ambiguity* (e.g., increased number of targets at varying location, friend-or-foe discrimination; Bale et al., 2024). Nesting refers to the embedded nature of informational properties of a performance environment, where smaller features are nested within larger units (Gibson, 1979). Enemy combatants and civilians can be nested within a building, which is nested within a larger urban environment, nested within a larger cultural environment. These nested units interact with each other under contextual constraints, creating order in features of the environment (Chow et al., 2011; Juarrero, 2023). Nested units form a complex system, scaling many degrees of freedom within the performer-environment system. Therefore, task ambiguity emerges from a lack of attunement to the information available in one's dynamic performance environment, leading to uncertainty about how to navigate the surroundings to achieve intended task goals.

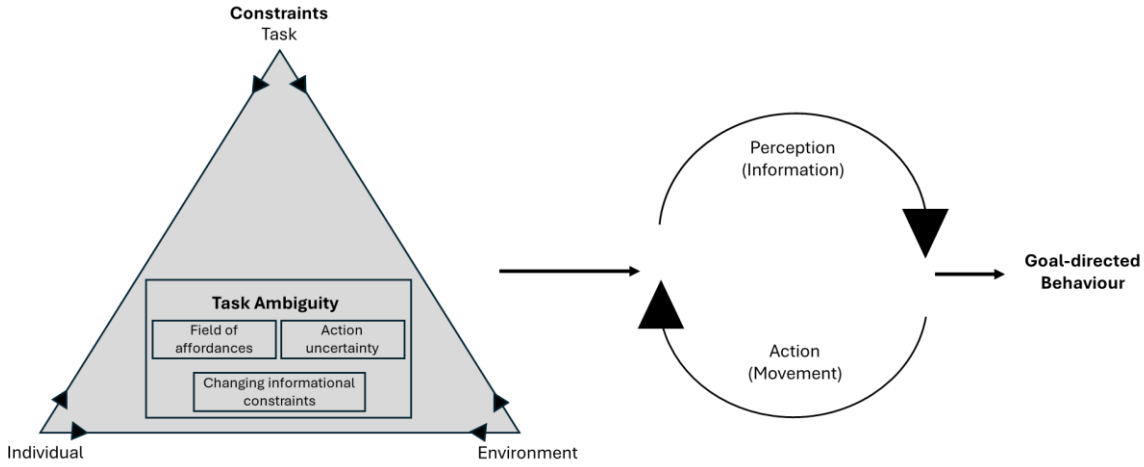
As task expertise increases with learning and experience, a strong coupling is formed between a performer and features (information) of the environment they inhabit. With practice, a performer can gain the ability to adapt (skilfully) to new environmental contexts, facilitated by a subtle blend of movement stability and flexibility (Araújo & Davids, 2011; Bennett & Fransen, 2023; Seifert et al., 2013). Task ambiguity is, therefore, less prominent in expert performance, supported by a loose, less rigid coupling between a performer and their environment. The lack of attunement to surrounding information leads to task ambiguity, where an agent (e.g., shooter) does not have adequate ‘knowledge of’ environmental features needed to navigate contexts to achieve their intended goals.

Next, we discuss how task ambiguity relates to the uncertainty of how a military operator could intentionally interact with different, available affordances, to inhibit how they may find their way through a combat landscape (Woods et al., 2020). Task ambiguity has

three interactive components (*Figure 1*): a field of affordances, action uncertainty, and changing informational constraints.

Figure 1.

Ecological Dynamics model envisaged with task ambiguity



Note. Task ambiguity arises as a function of the interacting constraints within a specific performance environment. If a combatant is not well attuned to the informational constraints in a performance environment, task ambiguity increases, shaping goal-directed behaviour and task success. Adapted from Davids et al. (2003).

Fields of Affordances

Affordances invite possible actions from performers (Gibson, 1979), existing in a landscape replete with features inviting possible interactions. An affordance landscape contains structured information flowing throughout the environment, offering, soliciting, and

inviting actions from a performer (Gibson, 1979; Rietveld, 2008; Withagen et al., 2012; Woods et al., 2020, 2021). Those affordances that are more soliciting of actions than others, form a 'field of affordances' (Bruineberg & Rietveld, 2014). Soliciting affordances are "the affordances that stand out as relevant for a particular individual in a particular situation" (Bruineberg & Rietveld, 2014, p. 2). They are, therefore, a subset of immediately available, soliciting affordances that are most relevant to a performer's capabilities and intentions, shaped by the task constraints within the performance environment (Bruineberg & Rietveld, 2014).

Instructors, trainers, and coaches can use task, individual, and environmental constraints to shape the fields of affordances available in practice for an athlete. For example, in team sports practice, coaches could employ various task constraints in small-sided games to develop desirable behaviours by reducing the number of players involved (including uneven teams) or changing pitch dimensions. Manipulating task constraints facilitates specific interactions, such as attacking/defending opportunities or running into space (Caso & van der Kamp, 2020; Fleay et al., 2018; Vilar et al., 2014). In combat shooting, a field of affordances could be changed by varying the number of targets to be engaged, the static-dynamic nature of these targets, and the need to discriminate between 'friend or foe' targets. Other features within the combat environment can also increase task ambiguity like different possibilities for seeking protective cover, ranging from open environments (fields, deserts) to urban dwellings (consisting of walls, enclosed rooms, windows).

The representativeness of these constraints within the field of affordances could also modify behaviours. For example, the use of cardboard targets that do not shoot back (with simulation ammunition) may not include affordances for cover in the field of affordances. The combatant does not require cover to navigate to their intended task goal successfully when there is no threat of being struck by a projectile. Whereas, an enemy combatant firing

simulation ammunition could extend the field of affordances to other features, like cover opportunities, leading to greater possibilities for combatants to search for specifying information associated with protective cover.

Changing the task constraints and information presented to combat shooters in training can continually modify the dynamic fields of affordances. This approach may shape the emergence of visual search behaviours (scanning or tracking a target) and coordinated actions, such as bringing a weapon to the target location, aiming and firing at an affordance (Davids et al., 2008; Williams et al., 2004). Therefore, trainers should seek to simulate and include constraints experienced in combat to provide realistic fields of affordances, facilitating the emergence of functional behaviours needed to dwell in a military environment and enhance survivability successfully.

Fields of affordances can create task ambiguity when it is not clear which affordances within the overarching affordance landscape a performer should attend to when exploring their task goals. Task ambiguity will grow with more affordances available within the performance landscape or when there is more instability in different nested features of the environment (e.g., more enemy combatants or civilians in close proximity to enemies). A performer will need time to perceive the information available in the performance landscape, which specifies how to act. In training combatants will need to learn to distinguish between specifying and non-specifying information in the environment. This perceptual skill will lead combat shooters to grow their knowledge of the performance environment by being attentive to information that solicits actions, to manage the ambiguity of modern military combative environments.

In training, combat shooters need to become attuned to surrounding information, which can specify available affordances as opportunities for support or harm. This means a

combat shooter's field of affordances in practice should simulate military features that can support or harm them, helping them learn their value and meaning. For example, a key element of survivability is mobility, which could be compromised in boggy landscapes within combat environments, compared to hard ground surfaces, which could afford faster movement and a more stable shooting platform for firing a weapon. A combat shooter would need to become attuned to what both terrains afford their actions. This would help them to understand how to traverse these combat environments and preserve their survivability.

The ecological concept of fields of affordances is congruent with the concept of a *taskscape* (performance environment; (Ingold, 2021; Woods et al., 2021). A taskscape is the "entire ensemble of tasks in their mutual interlocking" (Ingold, 2021, p. 195). Woods et al. (2021) emphasise 'mutual interlocking', that tasks are never encountered in isolation, but exist in an entanglement of people interacting with one another and with features of a performance environment. By attentively dwelling within specific performance environments during training, people can familiarise themselves with critical informational features, such as objects, events or others within that context (Ingold, 2021). Dwelling involves residing within an environment to gain knowledge of key informational properties and available affordances to 'know' how to wayfind through the taskscape (Woods & Davids, 2021) A combatant, therefore, cannot know how to act or what affordances to be responsive to, if not embedded within a training environment directly perceiving similar features which they will experience in combat (Pinder et al., 2011).

As Gibson (1979) noted, humans directly perceive information in their environment, gaining a 'knowledge of' its features. This notion of direct perception differs to cognitive psychology which advocates that perception is indirect. Indirect perception requires inference and relies on representations formed in the mind from previous experience in a task to shape action (Chamberlin & Magill, 1992; Gregory, 1974; Schmidt, 1988; Schmidt & Lee, 2011).

Gibson (1979) acknowledges that indirect perception is founded on 'knowledge about' environmental features. Knowledge about the environment is typically a secondary source, symbolic cognition modelling 'perceived reality' in the mind of shooters (Gibson, 1966, 1979). This sort of knowledge is more widely relied upon in traditional military training environments (e.g., based on instructions and order, maps, floorplans, graphics and images).

Indirect perception does not require a shooter to dwell in representative environments, as action is believed to be formed in the mind irrespective of environmental constraints (Raab & Araújo, 2019). However, the shortfall of this viewpoint is that it promotes second-hand (indirect) experience of the combat environment. It neglects the need for adapting skill and performance behaviours to changing information, and the need to navigate to specifying information and away from harmful affordances (Araújo et al., 2019; Gibson, 1979). For these reasons, in ecological psychology, goal-directed behaviour is regulated by 'knowledge of' the environment, information directly perceived and experienced.

In the combat context, combatants would benefit from dwelling in training environments with opportunities to experience differing possibilities for protection, engaging with varied target types and terrains, involved in events like property clearances. Dwelling in environments with these distinct features experienced in combat zones would develop knowledge of how one could interact with them (Warren, 1984, 2006; Woods et al., 2021). Training in environments that are linear, static and lacking features of actual combat environments could lead to combat shooters being unable to explore rich fields of affordances for wayfinding through combat. Combat shooters must experience relevant fields of affordances to develop knowledge of the combat environment, learning to find and utilise available affordances for achieving task goals, a process referred to as '*Enskilment*' (Ingold, 2021). Enskilment is an understanding in practice, where learning is inseparable from doing (Ingold, 2021). A combat shooter becomes enskilled when they can self-regulate actions to

find their way through the combative taskscape . To be enskilled is to be adaptable and responsive to the difficult-to-predict, ever-changing performance (e.g., combat) environment (Woods et al., 2021). Ingold's (2021) ideas, clarify that one only attunes to affordances available when dwelling attentively within the affordance landscape, thus developing 'knowledge of' its invariant features.

By gaining a deep understanding of the varying constraints of the field of affordances, coaches and practitioners can manipulate key constraints to design training environments that capture relevant information and opportunities for action. This idea is captured by Gibson's (1979) idea of *educating attention*, which accentuates the significance of guiding individuals to seek and find relevant sources of regulatory information through their interactions with a performance environment(Araújo & Davids, 2011; Jacobs & Michaels, 2007).

In training for combat shooting, the field of affordances should be designed to influence a combat shooter's situational awareness, mobility and lethality when developing performance during training and assessment. Practitioners should try to avoid designing training environments that do not include opportunities to enhance these key characteristics of shooters.

Action Uncertainty

The functional property of degeneracy in the human movement system has been previously discussed and evidenced (Seifert et al., 2013, 2016). Degeneracy is defined as "the ability of elements that are structurally different to perform the same function or yield the same output" (Edelman & Gally, 2001, p. 13763). The performer-environment system can

exhibit degenerate properties by nesting two structurally different features (e.g., an enemy target in uniform and an enemy dressed as a civilian), which could have the same output (both threaten combatant survivability through engaging in return fire).

Due to degenerate properties of combative military environments, action uncertainty increases with the close likeness of information that may specify fundamentally different actions (e.g., shoot/do not shoot). This is more challenging if a target (foe) masks their information, mimicking other information specifying different (e.g., non-threatening) actions and properties (e.g., using disguise to dress as a 'friendly' individual or deception to conceal a weapon). A common task in combat environments is the need to attune to information for 'friend-or-foe' discrimination to perceive a target's identity and what threat they may pose to a combatant. This will become a more significant requirement as conflicts become embroiled in urban areas, exacerbated by the area of future cities (OECD & European Commission, 2020).

Amid action uncertainty, an agent can 'attune' to specifying information within the field of affordances if exposed to it repeatedly in practice (Turvey, 1992). By spending time in a performance environment, attuning to relevant information whilst acting in a goal-directed way, the individual will develop an amplified attraction to soliciting affordances and a dampening of behaviour to other less soliciting (non-specifying) environmental features. Skill and expertise in combat shooters are predicated on the dampening of attraction to non-specifying information in identifying the correct targets. For example, when friendly and enemy targets wear the same clothes, combat shooters could learn to dampen their attunement to the dress of targets and amplify it to other relevant features, like expressions, postural stances, or hand-held implements (shape, textures and light-reflecting off an implement's metallic surfaces). By attuning to specifying information and attentively dwelling in combat

environments, action uncertainty will decrease as perception-action coupling of shooters strengthens and become more stable.

As a combat shooter learns to perceive specifying information within their environment, they gain a stronger understanding of the properties of the performance environment they inhabit and how those properties can be utilised. This understanding grows a combat shooter's knowledge of how an enemy combatant can manipulate key properties of the environment (e.g., civilians, objects, cover, or camouflage) and the possible ways they can utilise the environment to perturb and threaten opponent survivability.

Action uncertainty has been manipulated for years in combat by wearing camouflage to blend in with or mimicking other surrounding informational structures, challenging a shooter’s perception of specifying information. Identifying the friend-or-foe nature of targets wearing camouflage profoundly influences task completion times (Vera et al., 2022). Deception like this is also seen in sports contexts like basketball, where a player looking to shoot can perform deceptive movements such as head fakes, ball fakes and high-shot fakes to deceive defenders and make a shot at the basket easier (Meyer et al., 2022). Meyer et al. (2022) highlighted that more successful defending was associated with greater attunement to specifying hip and leg kinematic information. Fixating on the ball or an opponent’s head movements may not lead to task success, as they are the main instigators of the deceptive actions in basketball (non-specifying information). This is because movement-system degeneracy can be used to gain an advantage in the competitive context, by conveying deceptive information, increasing the uncertainty about the actions needed to defend the basket.

When navigating the taskscape, a combat shooter may be required to make a friend-of-foe decision. If not attuned to information, the shooter might perform the same action on

friendly targets as foes, especially with the high threat to life in combat environments, where a wrong decision could lead to reduced survivability. This risk is reduced with greater attunement and exposure to environmental information whilst attentively dwelling in the performance environment and experiencing its features to become an enskilled wayfinder (Woods et al., 2021).

Changing Informational Constraints:

Informational constraints change as one traverses the dynamic field of affordances; new affordances are realised, and old ones disappear (continually dissolving and emerging; (Guerin & Kunkle, 2004; Ingold, 2017). As combatants' navigate the environment, they perceive different information, which adapts their emergent interactions as constraints continuously change (Correia et al., 2013).

Changing information constraints is not unique to combat shooting; in sports contexts, a snooker player will have different affordances available on proceeding shots compared to preceding shots. For example, the position of the cue ball may not afford to pot the black if red balls are blocking a pocket, but previously it may have been a viable option.

Sailing regattas have rapidly varying emergent constraints at each event (changing wind direction and speed, currents, and other boat positions). Sailors often must adapt their behaviours planned before regatta events as constraints on the performers constantly change their field of affordances, soliciting different actions, which might be functional in one moment and dysfunctional in the following (Araújo et al., 2015).

Similarly, in combat, a foe target that afforded shooting previously due to engaging in a firefight, once out of ammunition and surrendering, no longer requires the same action (e.g., shoot) due to the constraints of the situation changing. In this way, changing informational constraints constantly shape the combative military environment (Guerin & Kunkle, 2004). If one is not attuned to these changes, an increased level of task ambiguity may be created.

Being attuned to changing informational constraints is harmonious with the ideas of enskilment and the concept of wayfinding from Ingold (2021). An enskilled wayfinder is responsive and attentive to subtle rhythms and patterns that emerge within their field of affordances (Woods et al., 2021) Wayfinding is an idea with implications for combat training designs. A recent scoping review (Bale et al., 2024) highlighted the infrequent use of unplanned protocols when testing combat shooting performance. Combat shooters in previous studies knew the location and dress of targets before starting tests (O'Donovan et al., 2023; Pedrosa et al., 2023; Talarico et al., 2023) Knowing exact target locations before starting a protocol is problematic as a combat shooter in a military zone rarely knows the exact locations of affordances or how those affordances will be presented within dynamic environments.

Implementing planned protocols reduces the possibilities of informational constraints changing within a combat shooter's field of affordances. Planned protocols could profoundly influence a combat shooter's attunement to the specifying features of combat shooting environments. For example, planned protocols could inhibit the development of visual scanning behaviours (Williams et al., 2004), shaping how one presents themselves in 'addressing' the environment (Travassos et al., 2012) (i.e., regulating body orientation for using cover while shooting), or how one can share affordances with others in a team (Silva et al., 2013). Not including dynamic informational constraints in training removes opportunities for enskilling a wayfinding combatant. (Travassos et al., 2012).

Attunement to possible changes within the combative environment is key when navigating towards a goal. It is a key feature lacking study in combat shooting research, yet the unplanned nature of combat is a critical constraint in this performance context (Bale et al., 2024). Military training is typically highly structured, partly due to the dangers involved and traditional military cultures, emphasising traditional 'command and control' strategies. Nevertheless, combat shooting training and coaching could be contemporised by concepts in ecological dynamics. These concepts could teach combat shooters to wayfind to important locations in adaptable ways to manage the changing constraints (Woods et al., 2021; Woods & Davids, 2021). One possible method to train shooters to attend to specifying information that is constantly changing is by simple questioning to guide the reflections and decision making of a combat shooter. Questions such as '*Where are possible locations of enemy combatants' or 'How could they use the terrain as cover*?' Responses to these questions do not need verbalising. Rather, understanding can be gauged by the combat shooters' actions and emergent behaviours as they navigate training contexts.

Practical Implications for Military Organisations

Earlier we alluded to Brunswik's (1956) representative design concept within the ecological dynamic's framework. Within the ecological dynamics literature, the concept of representative design has been applied to practice design, highlighting two key concepts: *action fidelity* (transfer of actions from training to the performance environment; (Araújo et al., 2007)) and *information functionality* (test environments need similar perceptual information as performance environments; (Pinder et al., 2011)). However, coaches also need to sample the task ambiguity of a specific performance context. For example, a cricket coach

could use an actual bowler in batting practice to maintain information functionality (Pinder et al., 2011), but this bowler might bowl similar balls constantly in training, or the fielders could occupy the same space throughout a practice session. In these cases, the information in the environment has remained somewhat stable, lacking contextual variation. To address this challenge, coaches could design instability into the training environment to foster task ambiguity to a representative level observed in competition to improve action fidelity and increase an athlete's adaptability.

In combat shooting methodologies, representative levels of task ambiguity in combat shooting could be achieved by changing target dress codes and hand-held implements, expanding the field of possible affordances (e.g., increasing the number of targets), and changing the constraints of different training tasks to promote the idea of ‘repetition without repetition’ (Bernstein, 1967).

Task ambiguity could help trainers to create high levels of uncertainty in training to replicate the changing information constraints of performance contexts. By wayfinding in representative affordance fields full of action uncertainty and changing information constraints, a combat shooter can be guided to form functional adaptive behaviours, which transfer directly from testing to military combative environments. This has been observed in competitive sport performance contexts (e.g., (Andrews et al., 2024).

As highlighted in Biggs et al. (2023), the combative environment is constantly changing, with opposing sides trying to outsmart each other’s tactical decisions and exploit weaknesses to gain competitive advantages. Biggs et al. (2023) discussed how combat shooting testing is heavily documented, decoupled into simpler task components, and highly regulated in large military organisations. This structured testing environment may not foster the conditions required for developing adaptive actions out in the field. High structure

mitigates changing information constraints, action uncertainty, providing stable, unchanging fields of affordances, leading to minimal task ambiguity and overly stable training environments. To develop knowledge of the environment and learn to wayfind through combative military environments with high levels of task ambiguity, a re-think of how combat shooters are trained and assessed is required.

Highly structured, decoupled training protocols which do not include representative task ambiguity are inadequate for assessing a combat shooter's survivability in these environments. When assessing combat shooting performance, practitioners should change the informational constraints of combat situations to understand the level of attunement to the combat environment dynamics.

Conclusion

In this position paper, we have suggested how an ecological dynamics theoretical framework can be used to create highly representative training environments in combat shooting. Training for shooters could exploit greater task ambiguity to address the lack of attunement between a performer and the dynamic military contexts which they inhabit. These ideas imply that practitioners should include a representative level of task ambiguity when assessing combatant survivability. To increase task ambiguity, practitioners should manipulate task constraints to create a challenging environment full of ‘safe uncertainty’, facilitating awareness of the dynamic, combative military environments (Woods & Davids, 2021).

Re-imagining combat testing is necessary to develop representative environments in training and assessment, an innovation in practice that could lead to better enskilment and survivability of combat shooters. Through the ecological dynamics approach, it may be

possible to understand the benefits of enhanced perception-action coupling. These theoretical ideas could improve understanding of how to manipulate constraints to shape the performance of combat shooters, helping them to manage the ambiguous, uncertain nature of modern military environments. The concept of task ambiguity is relevant for all performance contexts and not just combat shooting; it needs to be carefully implemented in skills training programmes.

References

Andrews, M. H., Gorman, A. D., & Crowther, R. H. (2024). Functional movement variability to maintain delivery speed in cricket fast bowling. *European Journal of Sport Science*, *24*(4), 415–421. https://doi.org/10.1002/ejsc.12045

Araújo, D., & Davids, K. (2011). What Exactly is Acquired During Skill Acquisition? *Journal of Consciousness Studies*, *18*(3–4), 7–23.

Araújo, D., Davids, K., Diniz, A., Rocha, L., Santos, J. C., Dias, G., & Fernandes, O. (2015). Ecological dynamics of continuous and categorical decision-making: The regatta start in sailing. *European Journal of Sport Science*, *15*(3), 195–202. https://doi.org/10.1080/17461391.2014.928749

Araújo, D., Davids, K., & Hristovski, R. (2006). The ecological dynamics of decision making in sport. *Psychology of Sport and Exercise*, *7*(6), 653–676. https://doi.org/10.1016/j.psychsport.2006.07.002

Araújo, D., Davids, K., & Passos, P. (2007). Ecological validity, representative design, and correspondence between experimental task constraints and behavioural setting: Comment on Rogers, Kadar, and Costall (2005). *Ecological Psychology*, *19*(1), 69–78. https://doi.org/10.1080/10407410709336951

Araújo, D., Hristovski, R., Seifert, L., Carvalho, J., & Davids, K. (2019). Ecological cognition: expert decision-making behaviour in sport. *International Review of Sport and Exercise Psychology*, *12*(1), 1–25. https://doi.org/10.1080/1750984X.2017.1349826

Bale, J., Perrett, C., Davids, K., Wheat, J., Jemma Coleman, Panchuk, D., & Middleton, K. (2024). The representative design of combat shooting methodologies from an ecological dynamics perspective: A scoping review. *International Journal of Sports Science & Coaching*, *0*(0), 1–21. https://doi.org/https://doi.org/10.1177/17479541241302379

Bennett, K. J. M., & Fransen, J. (2023). Distinguishing skill from technique in football. *Sci Med Footb*, *8*(4), 397–400. https://doi.org/10.1080/24733938.2023.2288138

Bernstein, N. (1967). *The co-ordination and regulation of movements* [Book]. Pergamon Press, Oxford.

Biggs, A., Hamilton, J., Huffman, G., & Markwald, R. (2023). The lethality paradox: Goodhart's Law and the challenge of measuring lethality. *Journal of Defense Modeling and Simulation*, *0*(0), 1–9. https://doi.org/10.1177/15485129231165527

Bruineberg, J., & Rietveld, E. (2014). Self-organization, free energy minimization, and optimal grip on a field of affordances. *Frontiers in Human Neuroscience*, *8*, 1–14. https://doi.org/10.3389/fnhum.2014.00599

Brunswik, E. (1956). *Perception and the representative design of psychological experiments.* (2nd ed. Berkeley) [Book]. University of California Press.

Busa, M. A., Palmer, C. J., & van Emmerik, R. E. (2015). Quantifying Survivability: An Ecological Analysis of Soldier Performance. Survivability: An Ecological Analysis of Soldier Performance. *In Studies in Perception and Action XIII: Eighteenth International Conference on Perception and Action. Psychology Press*, 5–10.

536 Caso, S., & van der Kamp, J. (2020). Variability and creativity in small-sided conditioned
537 games among elite soccer players. *Psychology of Sport and Exercise*, *48*, 1–7.
538 https://doi.org/10.1016/j.psychsport.2019.101645

539 Chamberlin, C. J., & Magill, R. A. (1992). The memory representation of motor skills: A test
540 of schema theory. *Journal of Motor Behavior*, *24*(4), 309–319.
541 https://doi.org/10.1080/00222895.1992.9941627

542 Chow, J. Y., Davids, K., Hristovski, R., Araújo, D., & Passos, P. (2011). Nonlinear pedagogy:
543 Learning design for self-organizing neurobiological systems. *New Ideas in Psychology*,
544 *29*(2), 189–200. https://doi.org/10.1016/j.newideapsych.2010.10.001

545 Clemente-Suárez, V. J., & Robles-Pérez, J. J. (2013). Mechanical, Physical, And
546 Physiological; Analysis of Symmetrical And Asymmetrical Combat. *Journal of Strength*
547 *and Conditioning Research*, *27*(9), 2420–2426. www.nsca.com

548 Correia, V., Araújo, D., Vilar, L., & Davids, K. (2013). From recording discrete actions to
549 studying continuous goal-directed behaviours in team sports. *Journal of Sports Sciences*,
550 *31*(5), 546–553. https://doi.org/10.1080/02640414.2012.738926

551 Davids, K., Button, C., & Bennett, S. (2008). *Dynamics of skill acquisition: a constraints-led*
552 *approach* (C. Button & S. Bennett, Eds.) [Book]. Human Kinetics.

553 Davids, K., Glazier, P., Araujo, D., & Barlett, R. (2003). Movement systems as dynamical
554 systems: the functional role of variability and its implications for sports medicine. *Sports*
555 *Medicine*, *33*(4), 245–260. https://www.researchgate.net/publication/10810355

556 Edelman, G. M., & Gally, J. A. (2001). Degeneracy and complexity in biological systems.
557 *Proceedings of the National Academy of Sciences*, 13763–13768.
558 https://doi.org/https://doi.org/10.1073/pnas.231499798

559 Fitch, H., & Turvey, M. T. (1978). On the control of activity: Some remarks from an
560 ecological point of view. In D. Landers & R. Christina (Eds.), *Psychology of Motor*
561 *Behavior and Sport* (Human Kinetics, Vol. 3, pp. 3–35). Champaign.

562 Fleay, B., Joyce, C., Banyard, H., & Woods, C. T. (2018). Manipulating field dimensions
563 during small-sided games impacts the technical and physical profiles of Australian
564 footballers. *The Journal of Strength & Conditioning Research*, *32*(7), 2039–2044.
565 https://doi.org/10.1519/JSC.0000000000002423

566 Gibson, J. J. (1966). The senses considered as perceptual systems. In *Houghton Mifflin.*
567 Houghton Mifflin.

568 Gibson, J. J. (1979). *The ecological approach to visual perception.* Houghton, Mifflin and
569 Company.

570 Gregory, R. L. (1974). *Concepts and mechanisms of perception.* London: Duckworth.

571 Guerin, S., & Kunkle, D. (2004). Emergence of Constraint in Self-organizing Systems.
572 *Nonlinear Dynamics, Psychology, and Life Sciences*, *8*(2), 131–146.

573 Handford, C., Davids, K., Bennett, S., & Button, C. (1997). Skill acquisition in sport: Some
574 applications of an evolving practice ecology. *Journal of Sports Sciences*, *15*(6), 621–
575 640. https://doi.org/10.1080/026404197367056

576 Ingold, T. (2017). *Anthropology and/as education* (1st ed.) [Book]. Routledge.
577 https://doi.org/https://doi.org/10.4324/9781315227191

578 Ingold, T. (2021). *The Perception of the Environment: Essays on Livelihood, Dwelling and*
579 *Skill* (1st ed.). Routledge.

580 Jacobs, D. M., & Michaels, C. R. (2007). Direct learning. *Ecological Psychology*, *19*(4), 321–
581 349. https://doi.org/10.1080/10407410701432337

582 Jensen, A. E., Bernards, J. R., Hamilton, J. A., Markwald, R. R., Kelly, K. R., & Biggs, A. T.
583 (2023). Don't Shoot Me: Potential Consequences of Force-on-Force Training Modulate
584 the Human Stress Response. *Journal of Strength and Conditioning Research*, *37*.
585 www.nsca.com

586 Juarrero, A. (2023). *Context changes everything: How constraints create coherence* (1st ed.).
587 The MIT Press. https://doi.org/https://doi.org/10.7551/mitpress/14630.001.0001

588 Lawson, B. D., Ranes, B. M., & Thompson, L. B. I. (2016). Smooth moves: Shooting
589 performance is related to efficiency of rifle movement. *Proceedings of the Human*
590 *Factors and Ergonomics Society*, 1523–1527.
591 https://doi.org/10.1177/1541931213601350

592 Meyer, J., Smeeton, N. J., Fasold, F., Schul, K., Schön, T., & Klatt, S. (2022). Shot deception
593 in basketball: Gaze and anticipation strategy in defence. *Human Movement Science*, *84*.
594 https://doi.org/10.1016/j.humov.2022.102975

595 Newell, K. M. (1986). *Constraints on the Development of Coordination.* (Wade Michael G. &
596 Whiting Harry T. A., Eds.). In Motor Skill Acquisition in Children: Aspects of
597 Coordination and Control.

598 Nibbeling, N., Oudejans, R. R. D., Cañal-Bruland, R., van der Wurff, P., & Daanen, H. A. M.
599 (2013). Pursue or shoot? Effects of exercise-induced fatigue on the transition from
600 running to rifle shooting in a pursuit task. *Ergonomics*, *56*(12), 1877–1888.
601 https://doi.org/10.1080/00140139.2013.847213

602 O'Donovan, M. P., Hancock, C. L., Bode, V. G., & Hasselquist, L. (2023). A comparison of
603 Expert and Novice marksmanship performance and postural mechanics using inertial
604 measurement units (IMUs) during dynamic live-fire shooting. *Applied Ergonomics*, *114*,
605 1–8. https://doi.org/10.1016/j.apergo.2023.104131

606 OECD, & European Commission. (2020). *Cities in the World: A New Perspective on*
607 *Urbanisation*. https://doi.org/10.1787/05384b8c-en

608 Passos, P., Araújo, D., Davids, K., & Shuttleworth, R. (2008). Manipulating Constraints to
609 Train Decision Making in Rugby Union. *International Journal of Sports Science &*
610 *Coaching*, *3*(1), 125–140. https://doi.org/10.1260/174795408784089432

611 Pedrosa, G. F., Kler, O. S., Rezende, L. F. S. P., Filho, H. L. dos S., Soares, Y. M., Avelar, E.
612 D., Souza, J. C. L. de, Cruz, P. W. da S., Laporta, L., & Figueiredo, L. S. (2023). Upper
613 and Lower Limbs Acute Fatigue Did Not Mitigate Male Trained Air Force Soldiers'
614 Marksmanship. *Perceptual and Motor Skills*, *0*(0), 1–19.
615 https://doi.org/10.1177/00315125231199813

616 Pinder, R. A., Davids, K., Renshaw, I., & Araújo, D. (2011). Representative Learning Design
617 and Functionality of Research and Practice in Sport. *Journal of Sport & Exercise*
618 *Psychology*, *33*, 146–155.

619 Raab, M., & Araújo, D. (2019). Embodied cognition with and without mental representations:
620 The case of embodied choices in sports. *Frontiers in Microbiology*, *10*(AUG).
621 https://doi.org/10.3389/fpsyg.2019.01825

622 Renshaw, I., & Chow, J. Y. (2019). A constraint-led approach to sport and physical education
623 pedagogy. *Physical Education and Sport Pedagogy*, *24*(2), 103–116.
624 https://doi.org/10.1080/17408989.2018.1552676

625 Rietveld, E. (2008). Situated normativity: The normative aspect of embodied cognition in
626 unreflective action. *Mind*, *117*(468), 973–997. https://doi.org/10.1093/mind/fzn050

627 Schmidt, R. A. (1988). Chapter 1 Motor and Action Perspectives on Motor Behaviour. In
628 Meijer. Onno & Roth. Klaus (Eds.), *Advances in Psychology* (Vol. 50, pp. 3–44).
629 https://doi.org/10.1016/S0166-4115(08)62551-0

630 Schmidt, R. A., & Lee, T. D. (2011). *Motor control: a behavioral emphasis.* Champaign IL:
631 Human Kinetics.

632 Seifert, L., Button, C., & Davids, K. (2013). Key properties of expert movement systems in
633 sport: An ecological dynamics perspective. *Sports Medicine*, *43*(3), 167–178.
634 https://doi.org/10.1007/s40279-012-0011-z

635 Seifert, L., Komar, J., Araújo, D., & Davids, K. (2016). Neurobiological degeneracy: A key
636 property for functional adaptations of perception and action to constraints. *Neuroscience*
637 *and Biobehavioral Reviews*, *69*, 159–165.
638 https://doi.org/10.1016/j.neubiorev.2016.08.006

639 Silva, P., Garganta, J., Araújo, D., Davids, K., & Aguiar, P. (2013). Shared knowledge or
640 shared affordances? insights from an ecological dynamics approach to team coordination
641 in sports. *Sports Medicine*, *43*(9), 765–772. https://doi.org/10.1007/s40279-013-0070-9

642 Talarico, M. K., Morelli, F., Yang, J., Chaudhari, A., & Onate, J. A. (2023). Estimating
643 marksmanship performance during walking while maintaining weapon aim. *Applied*
644 *Ergonomics*, *113*. https://doi.org/10.1016/j.apergo.2023.104096

645 Travassos, B., Duarte, R., Vilar, L., Davids, K., & Araújo, D. (2012). Practice task design in
646 team sports: Representativeness enhanced by increasing opportunities for action.
647 *Journal of Sports Sciences*, *30*(13), 1447–1454.
648 https://doi.org/10.1080/02640414.2012.712716

649 Turvey, M. T. (1986). Intentionally: A problem of multiple reference frames, specificational
650 information, and extraordinary boundary conditions on natural law. *Behavioral and*
651 *Brain Sciences*, *9*(1), 153–155. https://doi.org/10.1017/s0140525x00021944

652 Turvey, M. T. (1992). Affordances and Prospective Control: An Outline of the Ontology.
653 *Ecological Psychology*, *4*(3), 173–187. https://doi.org/10.1207/s15326969eco0403_3

654 Vera, J., Janicijevic, D., Miras-Moreno, S., Pérez-Castilla, A., Jiménez, R., Redondo, B., &
655 García-Ramos, A. (2022). Intraocular pressure responses to a virtual reality shooting
656 simulation in active-duty members of the Spanish Army: The influence of task
657 complexity. *Physiology and Behavior*, *256*, 1–6.
658 https://doi.org/10.1016/j.physbeh.2022.113957

659 Vilar, L., Esteves, P. T., Travassos, B., Passos, P., Lago-Peñas, C., Davids, K., & Mccormick,
660 B. (2014). Varying Numbers of Players in Small-Sided Soccer Games Modifies Action
661 Opportunities During Training. *International Journal of Sports Science & Coaching*,
662 *9*(5), 1007–1018.

663 Villa, J. D., Christopher, J. J., Mitchell, K. B., Hussey, E. K., Ramsay, J. W., & Brown, S. A.
664 T. (2019). Assessment of the Relationship between Military Weapon Qualification
665 Scores and Attributes of Simulated Marksmanship Mission Readiness. *Proceedings of*
666 *the Human Factors and Ergonomics Society Annual Meeting*, *63*(1), 1264–1268.
667 https://doi.org/10.1177/1071181319631073

668 Warren, W. H. (1984). Perceiving Affordances: Visual Guidance of Stair Climbing. *Journal of*
669 *Experimental Psychology: Human Perception and Performance*, *10*(5), 683–703.

670 Warren, W. H. (2006). The dynamics of perception and action. *Psychological Review*, *113*(2),
671 358–389. https://doi.org/10.1037/0033-295X.113.2.358

672 Williams, A. M., Davids, K., & Williams, J. G. (1999). *Visual Perception and Action in Sport*.
673 Routledge.

674 Williams, A. M., Janelle, C. M., & Davids, K. (2004). Constraints on the search for visual
675 information in sport. *International Journal of Sport and Exercise Psychology*, *2*(3), 301–
676 318. https://doi.org/10.1080/1612197x.2004.9671747

677 Withagen, R., Araújo, D., & de Poel, H. J. (2017). Inviting affordances and agency. *New*
678 *Ideas in Psychology*, *45*, 11–18. https://doi.org/10.1016/j.newideapsych.2016.12.002

679 Withagen, R., de Poel, H. J., Araújo, D., & Pepping, G. J. (2012). Affordances can invite
680 behavior: Reconsidering the relationship between affordances and agency. *New Ideas in*
681 *Psychology*, *30*(2), 250–258. https://doi.org/10.1016/j.newideapsych.2011.12.003

682 Woods, C. T., & Davids, K. (2021). "You Look at an Ocean; I See the Rips, Hear the Waves,
683 and Feel the Currents": Dwelling and the Growth of Enskiled Inhabitant Knowledge.
684 *Ecological Psychology*, *33*(3–4), 279–296.
685 https://doi.org/10.1080/10407413.2021.1965481

686 Woods, C. T., Rudd, J., Gray, R., & Davids, K. (2021). Enskilment: an Ecological-
687 Anthropological Worldview of Skill, Learning and Education in Sport. *Sports Medicine -*
688 *Open*, *7*(1). https://doi.org/10.1186/s40798-021-00326-6

689 Woods, C. T., Rudd, J., Robertson, S., & Davids, K. (2020). Wayfinding: How Ecological
690 Perspectives of Navigating Dynamic Environments Can Enrich Our Understanding of
691 the Learner and the Learning Process in Sport. *Sports Medicine - Open*, *6*(1).
692 https://doi.org/10.1186/s40798-020-00280-9

693