Psychon Bull Rev (2016) 23:1429–1439
DOI 10.3758/s13423-016-1006-9

THEORETICAL REVIEW

Can biological motion research provide insight on how to reduce friendly fire incidents?

Kylie A. Steel[1] · David Baxter[2] · Sera Dogramaci[3] · Stephen Cobley[4] · Eathan Ellem[5]

Published online: 5 February 2016

Abstract The ability to accurately detect, perceive, and recognize biological motion can be associated with a fundamental drive for survival, and it is a significant interest for perception researchers. This field examines various perceptual features of motion and has been assessed and applied in several real-world contexts (e.g., biometric, sport). Unexplored applications still exist however, including the military issue of friendly fire. There are many causes and processes leading to friendly fire and specific challenges that are associated with visual information extraction during engagement, such as brief glimpses, low acuity, camouflage, and uniform deception. Furthermore, visual information must often be processed under highly stressful (potentially threatening), time-constrained conditions that present a significant problem for soldiers. Biological motion research and anecdotal evidence from experienced combatants suggests that intentions, emotions, identities of human motion can be identified and discriminated, even when visual display is degraded or limited. Furthermore, research suggests that perceptual discriminatory capability of movement under visually constrained conditions is trainable. Therefore, given the limited military research linked to biological motion and friendly fire, an opportunity for cross-disciplinary investigations exists. The focus of this paper is twofold: first, to provide evidence for the possible link between biological motion factors and friendly fire, and second, to propose conceptual and methodological considerations and recommendations for perceptual-cognitive training within current military programs.

Keywords Biological motion · Friendly fire · Intention · Movement signatures · Recognition · Training

✉ Kylie A. Steel
k.steel@westernsydney.edu.au

[1] School of Science and Health, Western Sydney University, Penrith, 1797 Sydney, NSW, Australia

[2] Australian College of Physical Education, Sydney, Australia

[3] New South Wales Institute of Sport, Sydney, Australia

[4] University of Sydney, Sydney, Australia

[5] Western Sydney University, Sydney, Australia

Biological motion refers to the movements of living organisms (humans and animals) and has been examined in relation to the visual and auditory information conveyed to observers from movement, sound cues and social factors (Cottrell & Campbell, 2014; Johnson & Shiffrar, 2013; Schneider et al., 2014). While research concerned with various aspects of biological motion perception is increasing (e.g., auditory), the most significant body of research in this domain has been conducted by researchers concerned with the visual perception of biological motion and forms the basis of the work discussed here.

Visual biological motion perception research demonstrates that humans have an innate ability to detect and extract meaningful information from biological motion, including identity, emotion, and intention (Lu, 2010). Interestingly, while some real-world settings have applied biological motion research (biometrics, medical settings, safety garments, and sport). That said, there is minimal consideration for application in other settings, such as the (para) military settings (Steel, Ellem, & Baxter, 2015), despite logical association. Individuals in these professions must make numerous decisions under pressure, sometimes based on often confusing and seemingly contradictory visual information (i.e., visual clutter; Moberly & Langham, 2002; Tyrrell, Wood, Chaparro, Carberry, Chu, & Marszalek, 2009; Van Boxtel &

Lu, 2012)—events that can result in misidentification as well as decision-making and response errors. In the military context, the ability to recognize and identify familiar and nonfamiliars and their intentions from brief or limited biological movement information has potential in helping reduce close-combat friendly fire incidents.

The structure of this paper is first to set out and overview of friendly fire incidents in the military, followed by a brief overview of studies supporting the view that developed abilities exist in decoding perceptual information based on observation of movement permitting accurate person recognition, particularly in stressful situations. We then discuss the grounded emergence of developing perceptual ability in relation to sport (a ritualized, warfare-like context) and how it resembles perceptual-cognitive discrimination in dynamic, fast-paced changing environmental conditions of those engaging in teammate recognition environments. Finally, we put forward conceptual and methodological considerations that could be developed, tested, and applied in an effort to reduce friendly fire incidents.

Part 1: Friendly fire and operational settings (Combat)

The perceptual-cognitive ability to recognize and differentiate between various characteristics afforded from visual biological motion perception is important in numerous tasks, notably law enforcement, the military, or sport. In team invasion sports (e.g., football), the ability to distinguish "teammates" (friendlies) from "nonteammates" (hostiles) enables players to ensure that they pass the ball to one of their own rather than one of the opposing team. This perceptual ability also assists law enforcement or military personnel to distinguish the status (friendly or not) of others, within time and visually constrained contexts. If affiliation discrimination is inaccurate, friendly fire incidents may result (fratricide or blue on blue). Specifically, this is a situation or events where incorrect identification and recognition occur, leading to an allied individual or civilian being fired upon as if they were an enemy combatant (Rafferty, Stanton, & Walker, 2013).

Factors affecting perceptual information ability for operational personnel

Within the military context, detailed rules of engagement exist, and if followed should prevent friendly fire (Hart, 2005). However, human error exists despite many levels of procedure designed to minimize erroneous decisions and actions (see, e.g., Swiss Cheese Model; Reason, 2000). Hart (2005) suggests that preventing all cases of friendly fire is difficult because the causes are varied and complex with many factors to consider. For example, the maintenance of situational awareness is essential during combat operations and is characterized by individual and unit/squad knowledge and understanding of how actions impact current and future goals and objectives (Endsley, 2006, 2015). Moreover, combatants need situational awareness in regard to the local positions and movements of hostile forces while maintaining contact with command centers (Endsley, 2006).

The capacity to carry out such tasks is further complicated by constraints present in modern warfare where confusion regarding situational awareness can develop rapidly (Semple, 2008). Conflicts can be characterized by a fast tempo, often continuing 24 hours a day in landscapes relatively devoid of features (Hart, 2005) or in urbanized areas with high similarity (buildings) and with civilians present (Semple, 2008). Moreover, engaging with hostiles often occurs on the move with brief, interspersed glimpses of the enemy, and with many other objects (e.g., buildings, vegetation, people, vehicles), thus introducing visual clutter (Tyrrell et al., 2009). Combatants must therefore differentiate those within or beyond (optical sight) visual range, determine affiliation, and shoot to kill in a relatively reflexive manner, otherwise the affordance is lost.

Some research suggests that the use of technology (e.g., thermal imaging) with the aid of sufficient human interactions eliminates these types of errors (Kogler, 2003). However, the increasing rates of friendly fire indicate otherwise. For instance, the number of deaths during World War II (1939–1945) was 21 % of the estimated 23 million soldiers killed in combat, 17 % of an estimated 25,000 deaths (coalition and noncoalition forces) in the Persian Gulf War (1991), and up to 43 % of 4424 combat deaths in Operation Iraqi Freedom (2003–2010; Fischer, 2015; Greitzer & Andrews, 2013; Rafferty et al., 2012).

Cases of misrecognition of target affiliation, resulting in friendly fire

Numerous cases of friendly fire have been reported, particularly since the development of firearms, and regardless of the battle type (i.e., pitched compared to protracted); hence, incidents remain an ongoing feature of contemporary combat. A recent incident that relates to technology use in combat occurred in Basra in 2003. Thermal imaging displays, used by coalition forces, showed a number of "hot-spots" moving in and out of an object, and were interpreted as hostiles. The "hostiles" were then fired upon, resulting in the death of two soldiers and the injury of two others. Post examination found that the targets were all British soldiers (Rafferty, Stanton, & Walker, 2012). It is possible that thermal imaging limitations contributed to this error, as "body hot spots" can display in similar colors to areas in the surrounding environment (Han & Bhanu, 2005). Moreover, they may not display the intricate shape and movement patterns afforded by optical sources.

Furthermore, shadows can complicate the visual landscape and may have occluded key information for accurate perception, in addition to various materials that can be used to disguise thermal images from infrared cameras.

Another example occurred in Iraq, in 2008, where three American soldiers were killed, Pfc David Sharrett was part of an eight-soldier unit searching for unidentified individuals at night. He and his team wore night vision goggles (one eye) and infrared lights (only visible through the goggles) to aid familiar identification. In the time-pressured moments before engagement, team members were not reminded to turn on their lights, with some members, such as Pfc Sharrett, forgetting to do so. In the fire fight that followed, Sharrett moved into a position held by another team member, but was misidentified and shot (Jackman, 2012).

The Basra incident occurred beyond visual range while using technology with visual-imaging limitations, while PfC Sharrett was killed in close proximity under poor visual conditions (i.e., night), though with identification-enhancing technologies. However, numerous daytime examples have also occurred. Corp. Channing Day and Corp. David O'Connor were killed in 2012 when they inadvertently engaged in gunfire with on off-duty Afghan police officer in Afghanistan. They perceived him to be an armed member of the Taliban, as he was carrying a gun, which was not normal practice when off duty. Fellow police officers subsequently returned the soldier's fire in order to protect their fellow police officer, which resulted in the deaths of the two soldiers, whose role was to aid the local police (Swinford & Farmer, 2012).

The incident of Corp. Patrick Tillman provides further insight into the circumstances in which these incidents take place. Unlike cases before, Tillman was killed in daylight operations and in visual range of friendly forces. He and a number of other squad members lost physical and radio contact with their unit. When attempting to reestablish contact and rejoin his team, Tillman was fatally shot (Inspector General, 2007; Lee, 2011). The following investigation revealed that a coalition soldier recognized Tillman's uniform type as friendly, but proceeded to fire, while other members indicated Tillman was waving his arms and attempting to inform fellow combatants of his "friendly" status. Despite continued attempts, this information was not accurately interpreted.

Perceptual limitations of soldiers in friendly fire incidents

In each case presented, the target's intention and identity was incorrectly perceived. Factors leading to these perceptual errors possibly included coalition forces in unexpected locations and confusion as to the location of friendlies relative to hostiles, prompting the assumption of hostile intentions; loss of communication; coalition forces dressed differently when not on duty; failure to identify friendlies in low-light situations and when using technologies displaying limited visual information; and high psychological, cognitive, and physical stress. Despite these varying circumstances, and factors possibly affecting the outcome, a salient piece of information, consistently available in these incidents, was biological motion. Therefore, the utilization and improvement of biological motion information perception in operational settings has potential, given it has not been previously considered or explored, and could be beneficial in operational training preparation toward the reduction of friendly fire incidents.

Soldiers and other unit members engage in a variety of training programs that are designed to decrease errors resulting from strained perceptual-cognitive pathways (Matthews, Davies, Westerman, & Stammers, 2000), though these are not driven by biological motion concepts. Despite perceptual and cognitive training, situational awareness can still be compromised (confusion) and contribute to friendly fire incidents. While many factors contribute to erroneous decisions, especially given the extensive multisensory sources within the operational setting, the information perceived from movement is shown to be robust and could also be used to decrease misperception under time constraints.

Research demonstrates humans can, on average, detect various features from human motion, including emotions, identity, intentions, and action types (Blake & Shiffrar, 2007). Evidence also indicates that not all individuals are perceptually competent, and some features may be misinterpreted due to various forms of interference, including, visual clutter (Moberly & Langham, 2002), low light (Jackman, 2012), or visual occlusion (Steel & Dogramaci, 2015). The following section overviews some of the biological motion perception ability research. Such research studies, across various fields and contexts, help provide valuable insight and potential avenues for investigation and military operational setting.

Overview of biological motion research

Researchers in this domain primarily investigate the visual information derived from patterns of motion performed by humans and animals. They attempt to understand how we perceive, process, and interpret such information and what it tells us about the individual as well as the capabilities of the human body and the central nervous system (see Blake & Shiffrar, 2007; Johnson & Shiffrar, 2013, for reviews).

What does visual biological motion perception of gait tells us about others

Biological motion research demonstrates that humans have the nervous system infrastructure and capability to detect and recognize human movement, even when visual information is limited or constrained (spatially or temporally; Blake & Shiffrar, 2007; Jackson, & Blake, 2010). Furthermore, idiosyncratic features of movement, such as identity (Cutting & Kozlowski, 1977; Lu, 2010), gender (Kozlowski & Cutting, 1978), emotions (Dittrich, 1993; Stienen & deGelder, 2011), and movement intentions (Jackson, Warren, & Abernethy, 2006; Van Boxtel & Lu, 2012) can be identified.

Johansson (1973) was one of the first to investigate perception based on biological motion. In this seminal study, he found that observers were able to accurately detect walking gait conveyed by an early form of point-light displays (PLDs), which were placed on specific joints. Cutting and Kozlwoski (1977) extended this work to determine whether observers could recognize familars based on the veiwing of PLDs. The researchers filmed six individuals (three males, three females) performing a series of walks past a fixed video camera, with point-light displays attached to the ankles, knees, hips, wrists, elbows, and shoulders. Analysis of pretest data demonstrated that participants were able to recognize each other at levels above chance, though perfect scores were not achieved. They also suggested that factors such as arm swing, bounce, speed, and stride length were the cues used by observers for identification. One observer also used the nondynamic trait of height to determine familiarity and exhibited the lowest competency for this task (Cutting & Kozlwoski, 1977). At a 2-month follow-up test, participants demonstrated an increase in correct choices when detecting familiars, thus showing that identification accuracy increased with repeated viewing of video clips during testing, and most importantly, that gait identification learning was feasible.

Loula, Prasad, Harber, and Shiffrar (2005) corroborated these findings and also suggested that familiarity with the person observed in PLDs is a key element. In their experiments they found that observers were very good at identifying themselves from PLDs, most likely because they have the greatest knowledge of their own movements. Moreover, accuracy levels were high for friend identification which resulted from a familiarity with that person's movements, while stranger identification was at chance levels. The study also found that more exaggerated actions, such as boxing, dancing, and jumping, afforded additional idiosyncratic information compared to walking and running.

Recent biometrically driven research has corroborated early findings using more ecologically valid methods that combine specialized software with video surveillance footage. In the biometrics field, video footage (surveillance) of individuals walking is compared to stored examples of surveillance footage and used for person identification (Boyd & Little, 2003; Stevenage, Nixon, & Vince, 1999). Unlike Loula et al. (2005), however, Yam, Nixon, and Carter (2004) found that running exaggerates gait signatures and increases recognition. This may be attributed to different types of stimuli, where video footage provides additional global information, such as shape. Johansson (1973) explained this by suggesting that in everyday perceptions, features such as shape and motion cues are combined.

Gender is another feature that can be extracted from biological motion. Johnson and Tassinary (2007) suggested that whereas body shape is the primary source for direct perception related to sex category (male/female), gender (masculine/feminine) may also be identified from movement patterns. Earlier investigations also suggested that the most valuable sources of information for gender discrimination were related to the spatial cues of joints (Hoenkamp, 1978), or centers of moment (Pollick, Kay, Heim, & Stringer, 2005). The center of moment is the neutral reference point around which the joints of interest, in this case, hips and shoulders (Eysenck & Keane, 2000), swing during a walking gait phase. Sway created by the hips and shoulders was also suggested as providing sufficient cues for gender recognition (Barclay, Cutting, & Kozlowski, 1978; Cutting, Proffitt, & Kozlowski, 1978), with lower body differences also aiding recognition (e.g., ankles; Hoenkamp, 1978; Kozlowski & Cutting, 1978). A limitation in these studies, however, is their reliance on using a side view of the walking participant, which obscures the observer's view of both hip and shoulder motion during movement. Mather and Murdoch (1994) and Troje, Westhoff, and Lavrov (2005) accounted for this, and with the aid of computer-generated PLDs indicating the joints of an actor, found that providing frontal views of the hip and shoulder point lights increased the rate of gender recognition.

Action type, emotion, and intention

In expanding biological motion research, Dittrich (1993) used PLDs to determine whether the type of movement affected recognition. His experiments involved the identification of locomotory (i.e., walking, jumping, and leaping), instrumental (i.e., hammering, ball bouncing, stirring, and lifting), and social (i.e., dancing, boxing, greeting, or threatening) actions. Unlike Loula et al. (2005), Dittrich showed that locomotory actions were recognized faster and more often than social interaction and instrumentation use, which solidifies the notion that gait affords meaningful information to the observer.

The kinematic patterns conveyed when humans express emotion (i.e., anger, fear, and anger; Clarke, Bradshaw, Field, Hampson, & Rose, 2005; Pollick, Lestou, Ryu, & Cho, 2002), intention (threat; Dittrich, 1993; Van Boxtel & Lu, 2012) or pursuit (Dittrich & Lea, 1994) within biological motion have also been explored, though the study by Dittrich and Lea (1994) utilized animated objects rather than PLDs to explore intentionality. In this area, data have been assembled from observation of PLD representations of emotive arm actions, such as anger (Pollick et al., 2002); whole body demonstrations of fear, joy, and love (Clarke et al., 2005); and different types of facial displays (Pollick, Hill, Calders, & Paterson, 2003). Collectively, results from these studies indicate that various action types, emotions, and intentions can be perceived by using the spatial and temporal cues available during presentation of the relevant movements. In addition, spatial alteration (exaggeration) does affect identification rates more than temporal alteration (duration), which appeared to have only a small effect (Hill & Pollick, 2000; Pollick et al., 2003). For instance, there would be a difference between an individual seeking cover to avoid being shot during combat (indicating a civilian) and seeking cover to return fire (indicating a soldier).

Perceiving deception from biological motion displays

The uniqueness of gait and its use as a biometric is well established. However, unlike fingerprints, gait is also considered a soft biometric, as it is amenable based on a number of factors that include drunkenness, load being carried, disease, pregnancy, shoe type, drunkenness (Yam et al., 2004), terrain, fatigue, as well as cultural artefacts such as "swagger" and "strut" (Boyd & Little, 2003). These changes prompt the question: Can gait and other actions be disguised to present deceptive movement patterns and confuse an observer's ability to identify a person and their intent?

Gunns, Johnston, and Hudson (2002) examined this notion from a victim selection perspective, as threatening situations often encourage people to walk differently compared to situations of safety. The motion change can be so pronounced that low confidence, for example, can be conveyed, with such individuals being more likely selected as a target for a criminal acts. Thus, the researchers investigated whether walkers could effectively deceive observers by conveying a more confident walk. Participants completed a number of activities, including altering their style of walking and participating in martial arts classes. The most compelling finding suggested that altering various aspects of gait was not only possible but could be done convincingly.

The finding is significant, as some research suggests humans are highly attuned to deceptive movements and can be easily detected. Richardson and Johnston (2005) required actors to first walk naturally past a digital video camera, then, on their second pass, to adopt a style of walking that they thought mimicked an older individual. Observers had to state whether the pair of walkers – observed as PLDs – were the same person or two different individuals. Correct identification of the actor as the same person was at a rate better than chance. However, those actors who shifted their weight (sway) were the hardest to identify; thus, weight-shifting may disrupt the kinematic features that normally characterize a person's gait. The study did not succeed, however, in having the deceptive walker identified as an older individual. It is conceivable that an individual attempting to disguise their gait can be detected, and this capacity should improve with training.

Sensitivity to deceptive movement is also evident when observing an individual lifting a weighted object, even when the actor gave the impression that the object was lighter or heavier than it was, across a number of trials. Observers successfully detected deception (Runeson & Frykholm, 1981). Therefore, given observers are able to perceive deception in movement and that disguising one's walk may draw attention rather than deceive, the potential usefulness of gait as a biometric for identification becomes pertinent in settings where personal and group safety is paramount.

Section summary

Numerous studies have shown that the features of biological motion can be recognized from brief and impoverished visual displays, including, action type, emotion (Clarke, Bradshaw, Field, Hampson, & Rose, 2005), identity (Cutting & Kozlowski, 1977), intention (Dittrich, 1993), and deception (Jackson & Mogan, 2007). In particular, the characteristics that allow the observer to achieve successful recognition are lateral sway, moment of center, shape (gender), action type, arm swing, bounce, exaggeration, speed, and stride length (Cutting & Kozlwoski, 1977). Moreover, it is "familiarity with others" that highlights an acquired knowledge of motion patterns (Hill & Pollick, 2000; Loula et al., 2005).

These factors are valuable to consider in the military combat landscape. Here, it is critical that personnel demonstrate the ability to correctly recognize and perceive the intention of their immediate peers, friendlies, and enemy when characteristics associated with clothing, uniforms, and cultural dress may not be visually available or when disguise and camouflage is being used. The idiosyncratic nature of biological motion may thus provide the valuable source of information useable for accurate person and intention recognition. In doing so, personnel may enhance their perceptual skills in order to minimize friendly fire incidents, when the combat landscape includes a combination of coalition, opposition forces and civilians in visually constrained and stressful conditions.

Part 2: Considerations for the application and training of biological motion perception in military operation settings

Anecdotal accounts of the perceptual abilities of soldiers

Numerous anecdotal accounts and incidents highlighting the importance of biological motion information in combat exist. For instance, World War I soldiers have described how in woodland night operations they needed to recognize members of their unit from their silhouette as their uniform color was not available as a distinguishing feature. Specifically, they state that it was the running signature of squad members that enabled this ability, though as suggested by Johansson (1973), shape features are likely to assist this perceptual process.

Beevor (2012) also recounts how D-Day troops, in an effort to avoid friendly fire, were instructed to use knives and grenades in night operations rather than guns. This would have allowed closer engagement, and thus fewer identification errors, as soldiers were more likely to not only see some features that aid affiliation discrimination but also hear idiosyncratic features. While visual biological motion perception is the focus of this paper, it is important to acknowledge that other sensory sources may contribute to the process as it affords additional information for decision making. Price and Hodge (1976) suggested that the equipment and uniforms of soldiers create unique sounds when in motion. Moreover, Cottrell and Campbell (2014) suggest that footfall sounds provide individualized signatures, not unlike walking gait signatures, all of which may contribute to a global perception of the recognition of a target.

Therefore, while biological motion research demonstrates a person's ability to recognize numerous features that would benefit from training, it is important to first examine possible pathways for the development of what many researchers believe is an innate ability. We propose that in addition to the knowledge that recognizing others and their intentions has for survival value within everyday settings, this ability may also be sharpened by sport or war minus the shooting (Orwell, 1945, 2003).

The development of a perceptual ability: Insights from ritualized warfare

Close examination of the history and development of invasion sports reveals significant similarities and relevance to battleground situations that may explain why individuals have a baseline ability to perceive others by their movement. The research suggests that humans, driven by a need for resources, have frequently engaged in practices of tribal warfare with neighboring groups, carried out in order to increase a tribe's chance of survival (M. H. Johnson, 2006; LeBlanc & Register, 2003; Wade, 2006). To prepare for these interactions, some cultures have historically participated in ritualized warfare, that is, early forms of team sports. Ritualized warfare would have capitalized on the development of a number of tactically based perceptual skills, such as reading the play, moving into space, and possibly identifying teammates by the way they run.

An early example is Baggataway, or the "little (younger) brother of war," which was a team sport, played by early Native American Indians, considered to be the predecessor of modern lacrosse. The current view is that the game evolved from a spiritual beginning as a method of honoring ancient gods and developing skills related to battle, with Vennum (2007) asserting that no other game is more explicit about its origins in tribal warfare than lacrosse.

Like modern invasion sports, early versions of lacrosse required the invasion of the opposition's territory to score a goal. This also requires fast ball passing that is vulnerable to intercept affordances for both teams (E. F. Gibson, 2002; J. J Gibson, 1986). Earlier versions of lacrosse also had greater importance within Native American Indian cultures, as it was a forum for tribal preparation for close combat (Morrill, 1952), and a method to resolve disputes between neighboring tribes (Vennum, 2007). Within Native American Indian cultures, a variety of playing constraints existed, including the involvement of both genders, a stick in one or both hands, some 12 to thousands of players, and goals from 120 feet to several miles apart. Games could also be played over a number of days. They deemed this type of game play as an excellent tool for military training, as it would have improved perceptual skill for fast decisions, including reading the play, and tactical awareness in addition to physical fitness (McCoy, 2004; Morrill, 1952; Cohen, Pietrmala, & Grauer, 2006).

Contemporary forms of invasion sports, including football (all codes), hockey (field, ice), basketball, and water polo (Contreras Jordán, Garcia López, & Cervelló Gimeno, 2005) still contain many of the same principles developed in earlier invasion games and resemble combat-related skills. These include skills that maximize team (tribe) success, such as cooperating with teammates; perceiving tactical movement; and detecting direction, speed, and capability in a combat landscape. Consequently, some research from sport science could hold potential relevance and application to combat training, particularly from a visual perception and decision-making viewpoint.

A sport science research explanation for perceptual ability limitations of soldiers

The body of research that demonstrates a person's ability to recognize others, emotions, and intentions from movement is extensive, with recent research in the sport sciences suggesting skill development in invasion team sports players. Steel and colleagues (Steel, Adams, & Canning, 2006, 2007, 2008; Steel & Eisenhuth, 2012) have conducted a series of experiments in invasion sports, with the impetus arising from anecdotal accounts of wartime veterans discussing night operations and in recognizing their squad members from hostiles based on the way they moved. They proposed that if soldiers learn this skill with no explicit training, then so, too, can invasion sport athletes. Furthermore, based on early findings in the biological motion field (Kozlowski & Cutting, 1978), they also proposed that the skill could be systematically trainable.

Using a simple video and computer software design, Steel, Adams, and Canning (2007, 2008) found that invasion games athletes (junior and senior) were able to discriminate "familiar and unfamiliar" peers based on viewing brief visual clips of teammates and nonteammates during locomotion.

Furthermore, subsequent studies demonstrated that athletes had the capacity to perform this task in sport relevant time (<500 ms; Steel, Adams, Canning, & Eisenhuth, 2010; Steel & Dogramaci, 2015). In each study, participants displayed significantly above chance levels for discrimination accuracy, although some members performed close to chance. The latter finding perhaps holds the most meaning and significance for application to both sport players and soldiers. Both are required to engage, interact with, recognize, and detect the intention of teammates (friendlies) and opposition (hostiles) in time and visually constrained situations, and in sport, experienced players are empirically and anecdotally shown to have superior skills (e.g., better discrimination accuracy, anticipating more correctly, making better tactical decisions, technically responding more appropriately). Inexperienced players, however, demonstrate more limitations with regard to perceptual-cognitive skills, which may also be the case for soldiers, leading to misidentification and subsequent friendly fire.

Additional data analysis in the Steel, Adams, and Canning (2012) investigation demonstrates that accuracy decreased when distinguishing athletes in a less familiar context. Moreover, when viewing footage of less familiar gait types (skating) where players also wore heavy equipment, accuracy also declined (Steel & Dogramaci, 2015). These points are crucial for combat situations, as the exact landscape cannot always be replicated in training or determine exactly how someone will move with bulky equipment in the midst of combat.

Therefore, while the military engages in extensive training programs that enhance the motor and perceptual skills of personnel, including identification and acquisition of targets in combat (Bryant & Smith, 2011; Famewo, Matthews, & Lamoureux, 2007), these programs do not specifically address the enhancement of identification based on biological motion cues. Therefore, training, that at the very least addresses these issues, even implicitly, holds some benefit. This type of protocol, with brief biological movement exposure coupled with collections of data on decision accuracy, chronometry, and decision efficacy, presents an appropriate methodological approach for the investigation of perceptual skill training. In particular, an obvious link exists between this research in the military context, based on the evolution of invasion games from ritualized warfare as well as decision accuracy and time constraints of both settings.

Considerations and recommendations for testing and training perceptual abilities related to biological motion

Insights from biological motion and sport science research, conducted in sport settings, suggest that, on average, people are competent at recognizing others from movement. However, in a military operation setting, this is not sufficient, as errors can result in death or injury. Therefore, it is important, first, to determine which personnel are likely to engage in close combat settings, and of these individuals, which have deficits in the perceptual ability to recognize others and their intentions from biological motion information.

Testing visual biological motion perception ability

The identification of such personnel can be accomplished by using simple testing methods, such as those used by Steel et al., (2010). Video footage of teammates and nonteammates were temporally occluded and formulated a randomized sequence whereby observers used a latency device to indicate teammate affiliation and confidence in this decision. The temporal occlusion was designed to reflect the occurrence of time constraints within a game situation and is a relevant factor for soldiers in combat. The observers also viewed footage of familiar and nonfamiliar views of others, also an important consideration for military applications derived from biological motion.

Military engagements are complex and varied with scenarios sometimes deviating from planned actions or operations; consequently, soldiers may encounter situations that produce decreased situational awareness, leading to confusion (e.g., losing radio contact, as in the case of Patrick Tillman). Hence, testing strategies that provide increased ecological validity by reflecting the specific operational needs of the unit, combined with perception of biological motion, are also likely to be useful (Greitzer & Andrews, 2013). Indeed, a number of studies have shown that less experienced soldiers and their unit leaders are prone to decreased levels of situational awareness as the complexity of the environment increases and are therefore more likely to be involved in friendly fire (Shattuck, Graham, Merlo, & Hah, 2000). This arises as inexperienced leaders, while maintaining a good awareness of the location of friendlies, are not as able in regard to hostiles; thus, in situations where both groups engage in face-to-face combat, confusion results, and hence, an ecologically valid test sequence is essential.

Test sequences could specifically include the manipulation of the video stimulus to show a variety of movements captured in different contexts such, as those with low light (dawn, dusk, and night), diverse environments (desert, jungle, arctic, or urbanized; Endsley 2006), and with varying levels of visual clutter (humans, animals, and machines; Mayer, Vuong & Thorton, 2015). Furthermore, multisensory factors present in operational settings should be considered, including excessive sounds, extreme temperatures, and relevant and irrelevant moving objects, which challenge the attentional capacity of the observer. The use of footage gained from actual operations would further augment the realistic nature of the test setting, with simulation and virtual reality constructs also holding some value (Holliday, 2013).

Additional consideration should be given to the type of device used to capture decision choice and latency data. These devices are easily constructed by technical staff; however, to increase ecological validity, it is conceivable that the latency device may include trigger-type buttons as opposed to those used in other latency studies (Li, Liang, Kliener, & Lu, 2010). This would provide similar information (recognition accuracy, confidence in the decision, reaction time and movement time); however, the use of a more ecological validity (ergonomically designed) system similar to those used during operations is advantageous. Specifically, assessors could determine expertise levels of individuals in relation to the accuracy of the decision (perception) in comparison to how quickly participants move to pull the trigger (execution). This distinction is important, as training can be designed to address either or both deficits and, given the fast tempo of engagement, which should result in reflexive (below conscious) responses when correct target acquisition has occurred, to take advantage of brief affordances (J. J. Gibson, 1986; E. F. 2002).

Training visual biological motion perception ability

When base-level ability has been established and defined (perceptual vs. execution), individuals with scores sitting below a determined threshold could engage in additional, though not intrusive, training programs. Sport science research in the area of motor learning provides evidence for a number of considerations when using various strategies for training perceptual-cognitive skills that may be beneficial in the military context.

Breslin, Hodges, Williams, Curran, and Kremer (2005) demonstrated that individuals can improve movement proficiency when observing video footage of movement performances that were overlaid with PLDs on specific joints. This directs the attention of the observer toward the relative information conveyed by joint movement patterns. Furthermore, the use of color coding, whereby translucent dots are superimposed onto joints within video training clips, has resulted in improved perceptual and motor skills for sports people performing volleyball actions (Hagemann, Strauss, & Canal-Bruland, 2006). In the military training context, these types of methods could be used to construct videos, captured ideally from real operations, and superimpose PLDs or translucent dots upon the joints or segments of the friendly forces within the sequence. This would draw the observers' attention to the relevant joints and motion patterns of individuals within the unit, in addition to the manner in which "friendlies" move compared to those trying to deceive.

Gaze training provides another training option that has been used successfully in both the sport and surgical domains. Investigations of the gaze habits of experts found that individuals who observed the gaze patterns of experts increased their perceptual and motor skills significantly compared to controls (Wilson, Vine, Bright, Masters, Defriend, & McGrath, 2011; Vine, Masters, McGrath, Bright, & Wilson, 2012). The authors suggest that observing these patterns expedites learning; hence, in an operational setting, recognition based on movement signatures may be useful, especially where units are combined or new members are recruited.

Specifically, video footage can be captured while soldiers are engaging in simulated exercises, which can then be used as a test and training stimulus. The recorded gaze patterns of personnel with superior recognition abilities could then be viewed by members of the unit that demonstrate perceptual deficits for this type of task, thus directing the observers attention to the critical cues that allow accurate recognition. Critically, Shi, Weng, He, & Jiang (2010) state that biological motion detection captures attention in a reflexive manner. Thus, if soldiers with deficits engage in ideal gaze-training methods, they may be able to take advantage of this innate reflexive ability and enhance their biological motion perceptual abilities in the operational setting.

These suggested training methods have promise in the military setting; however, we suggest that it is also important to consider the limitations of approaches that use directed or explicit cues and instructions. Zhu et al., (2011) found that motor skills (perceptual-cognitive) learned using explicit methods (verbal-analytic) are prone to break down when applied in physically or psychological stressed situations. Individuals using these methods are more likely to concentrate on each step required to complete a task rather than allowing automaticity and results in the use of attentional space that could otherwise be used for other decision making process.

Consequently, given combat situations are inherently stressful applied methods should be adjusted to ensure more implicit development of the biological motion skills (Poolton, Wilson, Malhotra, Ngo, & Masters, 2011; Malhotra, Poolton, Wilson, Omuro, & Masters, 2015). This could include participation in invasion sport during training or nontraining time, which can facilitate this process by specifically ensuring that team members wear the same attire as nonteam members. In doing so, the focus is on movement cues that complement shape and facial cues but do not rely on uniform-based cues.

Similar approaches can be integrated into physical maneuvers where members of different squads engage in physical exercises at dusk or dawn wearing exactly the same attire and carrying the same equipment. In this case, the only visible features will be anthropometric, or those based on movement. The reverse would hold when asking one side to dress as hostiles and move with the intention to harm. Numerous benefits exist that include discrimination based on biological motion rather than uniform type and color, which is absent in low-light situations. Moreover, if the opposing participants have authentic armaments used by hostiles, they, first, form certain types of silhouettes and, second, will be forced to move using an altered gait.

It is essential that a variety of tools are used when capturing video footage for testing and training. Previous research has used stationary cameras; however, greater ecological validity (E. G. Gibson, 2002; J. J. Gibson, 1986) would be evident if the footage was captured using devices such as GoPro action cameras or military-grade versions. Another benefit of training biological motion recognition is that identity and intention (deception) can be used as a signature or conversely trained to deceive others (hostiles). In doing so, more time may be afforded for protective measures if hostiles are attempting to mimic friendlies' behaviors to move closer to them for threatening purposes.

Conclusions

The purpose of this paper was to present the link between biological motion perception and its relevance to combat situations. We propose that this research provides an argument for the inclusion of biological motion concepts in the development of protocols that detect perceptual deficits that may leave personnel vulnerable to friendly fire situations, and for the development of specialized training programs. While the applied nature of the research is scarce and warrants further research, it has been afforded some attention in the development of safety apparel (Owens, Antoff, & Francis, 1994), medicine (Murray, Drought, & Kory, 1964), and especially biometrics (Makihara et al., 2015). However, it is the potential applications for the reduction of friendly fire that are most compelling.

In conclusion, friendly fire in close combat is an ongoing military issue that has been all too prevalent in modern warfare. The impact of these events is broad and affects both individuals and their organizations in relation to trust and pace of engagement. While the human element is only one portion of the friendly fire link, it is the one aspect that is likely to result in repeated similar errors of judgement regardless of technological advances. Hence, research in this setting may benefit a perceptual-cognitive training program aimed at military contexts. Given that not all engagements occur with optimal light or clarity, soldiers could be trained first to recognize biological motion where human form is degraded because of environmental conditions (dust, time of day) and, second, to identify whether this person is friendly or not. We suggest this would have the greatest impact in smaller groups (units) where familiarity with others is achievable; however, recognition of intention from biological motion is possible regardless of familiarity. It is also conceivable that the perception of intention from biological motion augments the perception of recognition; however, further research is required to determine this relationship. In conclusion, more research is warranted in order to determine the most efficient application of these methods in high-pressure, close-combat battlefield scenarios.

Acknowledgments The first author would like to thank Dr. Roger Adams for his continued guidance in the conceptual design of the TM-ID test paradigm and its applications in sport and military settings, and for providing the original idea that serves as the impetus for this work.

References

Barclay, C. D., Cutting, J. E., & Kozlowski, L. T. (1978). Temporal and spatial factors in gait perception that influence gender recognition. *Perception & Psychophysics, 23*(2), 145–152.

Beevor, A. (2012). *D-Day: The battle of Normandy.* London: Penguin Books Limited.

Blake, R., & Shiffrar, M. (2007). Perception of human motion. *Annual Review Psychology, 58,* 47–73. doi:10.1146/annurev.psych.57.102904.190152

Boyd, J. E., & Little, J. J. (2003). Biometric gait recognition. In M. Tistarelli, J. Bigun, & E. Grosso (Eds.), *Advanced studies in biometrics: Summer school on biometrics* (pp. 19–42). Halmstad: Springer.

Breslin, G., Hodges, N. J., Williams, A. M., Curran, W., & Kremer, J. (2005). Modelling relative motion to facilitate intra-limb coordination. *Human Movement Science, 24*(3), 446–463.

Bryant, D. J., & Smith, D. G. (2011). *Comparison of identify-friend-foe and blue-force tracking decision support for combat identification.*

Clarke, T. J., Bradshaw, M. F., Field, D. T., Hampson, S. E., & Rose, D. (2005). The perception of emotion from body movement in point-light displays in interpersonal dialogue. *Perception, 34*(10), 1171–1180.

Cohen, K., Pietramala, D. G., & Grauer, N. A. (2006). *Lacrosse: Technique and tradition* The Second Edition of the Bob Scott Classic.

Contreras Jordán, O. R., Garcia López, L. M., & Cervelló Gimeno, E. (2005). Transfer of tactical knowledge from invasion games to floorball. *Journal of Human Movement Studies, 49*(1), 193–213.

Cottrell, D., & Campbell, M. E. (2014). Auditory perception of a human walker. *Perception, 43*(11), 1225–1238.

Cutting, J. E., & Kozlowski, L. T. (1977). Recognizing friends by their walk: Gait perception without familiarity cues. *Bulletin of the Psychonomic Society, 9*(5), 353–356.

Cutting, J. E., Proffitt, D. R., & Kozlowski, L. T. (1978). A biomechanical invariant for gait perception. *Journal of Experimental Psychology. Human Perception and Performance, 4*(3), 357.

Dittrich, W. H. (1993). Action categories and the perception of biological motion. *Perception, 22*(1), 15–22.

Dittrich, W. H., & Lea, S. E. G. (1994). Visual perception of intentional motion. *Perception, 23*(3), 253–268.

Famewo, J., Matthews, M., & Lamoureux, T. (2007). *Modele du Regroupement de L'information Concernant L'identification au Combat: Une Analyse Documentaire [Models of information aggregation pertaining to combat identification: A review of the literature].* Guelph: Humansystems.

Fischer, H. (2015). *A guide to U.S. military casualty statistics: operation freedom's sentinel, operation inherent resolve, operation new dawn, operation Iraqi freedom, and operation enduring freedom.* Washington: Congressional Research Service.

Endsley, M. R. (2006). Expertise and situation awareness. In K. A. Ericsson, N. Charness, R. R. Hoffmann, & P. J. Feltovich (Eds.), *The Cambridge Handbook of expertise and expert performance* (pp. 633–651). New York: Cambridge University Press.

Endsley, M. R. (2015). Situation awareness misconceptions and misundertsandings. *Journal of Cognitive Engineering and Decision Making, 9*(1), 4–32.

Eysenck, M. W., & Keane, M. T. (2000). *Cognitive psychology: A student's handbook.* Taylor & Francis.

Greitzer, F. L., & Andrews, D. H. (2013). Training strategies to mitigate expectancy-induced response bias in combat identification: A research agenda. In D. H. Andrews., R. P. Herz., & M. B. Wolf (Eds.), *Human factors issues in combat identification* (pp. 173–198).

Gibson, E. F. (2002). *Perceiving the affordances: A portrait of two psychologists*. London: Erlbaum.

Gibson, J. J. (1986). *The ecological approach to visual perception*. London: Erlbaum.

Gunns, R. E., Johnston, L., & Hudson, S. M. (2002). Victim selection and kinematics: A point-light investigation of vulnerability to attack. *Journal of Nonverbal Behavior, 26*(3), 129–158.

Hagemann, N., Strauss, B., & Cañal-Bruland, R. (2006). Training perceptual skill by orienting visual attention. *Journal of Sport and Exercise Psychology, 28*(2), 143.

Han, J., & Bhanu, B. (2005). Human activity recognition in thermal infrared imagery. *In Computer Vision and Pattern Recognition-Workshops, 2005. CVPR Workshop*s. *IEEE Computer Society Conference on* (pp. 17–17). San Diego: IEEE. doi:10.1109/CVPR.2005.469

Hart, R. J. (2005). Preventing fratricide: A complex problem with no easy solutions. *Military Technology, 29*(11), 40–49.

Hill, H., & Pollick, F. E. (2000). Exaggerating temporal differences enhances recognition of individuals from point light displays. *Psychological Science, 11*(3), 223–228.

Hoenkamp, E. (1978). Perceptual cues that determine the labeling of human gait. *Journal of Human Movement Studies, 4,* 59–69.

Holliday, J. (2013). *Effect of stroboscopic vision training on dynamic visual acuity scores: Nike vapor strobe® eyewear.*

Inspector General, U. S. D. O. D. (2007). *Review of matters related to the death of Corporal Patrick Tillman*. Washington: U.S. Army.

Jackman, T. (2012). David Sharrett's familiy still wants justice for friendly fire death in Iraq. *The Washington Post.*

Jackson, R. C., & Mogan, P. (2007). Advance visual information, awareness, and anticipation skill. *Journal of Motor Behavior, 39*(5), 341–351.

Jackson, S., & Blake, R. (2010). Neural integration of information specifying human structure from form, motion, and depth. *The Journal of Neuroscience, 30*(3), 838–848.

Jackson, R. C., Warren, S., & Abernethy, B. (2006). Anticipation skill and susceptibility to deceptive movement. *Acta Psychologica, 123*(3), 355–371.

Johansson, G. (1973). Visual-perception of biological motion and a model for its analysis. *Perception and Psychophysics, 14*(2), 201–211.

Johnson, K. L., & Shiffrar, M. (2013). *People watching: Social, perceptual, and neurophysiological studies of body perception*. New York: Oxford University Press.

Johnson, K. L., & Tassinary, L. G. (2007). Compatibility of basic social perceptions determines perceived attractiveness. *Proceedings of the National Academy of Sciences, 104*(12), 5246–5251.

Johnson, M. H. (2006). Biological motion: a perceptual life detector? *Current Biololgy, 16*(10), R376–377. doi:10.1016/j.cub.2006.04.008

Kogler, T. M. (2003). *The effects of degraded vision and automatic combat identification reliability on infantry friendly fire engagements* (Doctoral dissertation, Virginia Polytechnic Institute and State University).

Kozlowski, L. T., & Cutting, J. E. (1978). Recognising the gender of walkers from pointlights mounted on ankles: Some second thoughts. *Perception and Psychophysics, 23*(5), 459.

LeBlanc, S. A., & Register, K. (2003). *Constant battles*. New York: St. Martin's Press.

Lee, T. (2011). *Motor control in everyday actions*. Champaign: Human Kinetics.

Li, X., Liang, Z., Kleiner, M., & Lu, Z. L. (2010). RTbox: A device for highly accurate response time measurements. *Behavior Research Methods, 42*(1), 212–225.

Loula, F., Prasad, S., Harber, K., & Shiffrar, M. (2005). Recognizing people from their movement. *Journal of Experimental Psychology. Human Perception and Performance, 31*(1), 210.

Lu, H. (2010). Structural processing in biological motion perception. *Journal of Vision, 10*(12), 13. doi:10.1167/10.12.13

Makihara, Y., Matovski, D. S., Nixon, M. S., Carter, J. N., & Yagi, Y. (2015). *Gait recognition: Databases, representations, and applications*. Wiley Encyclopedia of Electrical and Electronics Engineering.

Malhotra, N., Poolton, J. M., Wilson, M. R., Omuro, S., & Masters, R. S. (2015). Dimensions of movement specific reinvestment in practice of a golf putting task. *Psychology of Sport and Exercise, 18,* 1–8.

Mather, G., & Murdoch, L. (1994). Gender discrimination in biological motion displays based on dynamic cues. *Proceedings of the Royal Society of London B: Biological Sciences, 258*(1353), 273–279.

Matthews, G., Davies, D. R., Westerman, S. J., & Stammers, R. B. (2000). *Human performance: Cognition, stress, and individual differences*. New York: Psychology Press.

Mayer, K. M., Vuong, Q. C., & Thornton, I. M. (2015). Do people "pop out"? *PloS One, 10*(10), e0139618.

McCoy, L. (2004). *Sports injuries: How to prevent, diagnose and treat–Lacrosse*. Broomall, PA: Mason Crest.

Moberly, N. J., & Langham, M. P. (2002). Pedestrian conspicuity at night: failure to observe a biological motion advantage in a high-clutter environment. *Applied Cognitive Psychology, 16*(4), 477–485.

Morrill, W. K. (1952). *Lacrosse*. New York: A. S. Barnes.

Murray, M. P., Drought, A. B., & Kory, R. C. (1964). Walking patterns of normal men. *Journal of Bone and Joint Surgery, 46*(2), 335–360. Retrieved from http://jbjs.org

Orwell, G. (1945). The sporting spirit. *The Tribune*.

Orwell, G. (2003). *Shooting an elephant*. London: Penguin UK.

Owens, D. A., Antonoff, R. J., & Francis, E. L. (1994). Biological motion and night-time pedestrian conspicuity. *Human Factors, 36*(4), 718–732.

Pollick, F. E., Hill, H., Calders, A., & Paterson, H. (2003). Recognising facial expression from spatially and temporally modified movements. *Perception, 32*(7), 813–826.

Pollick, F. E., Lestou, V., Ryu, J., & Cho, S. B. (2002). Estimating the efficiency of recognising gender and affect from biological motion. *Vision Research, 42*(20), 2345–2355.

Pollick, F. E., Kay, J. W., Heim, K., & Stringer, R. (2005). Gender recognition from point-light walkers. *Journal of Experimental Psychology. Human Perception and Performance, 31*(6), 1247.

Poolton, J. M., Wilson, M. R., Malhotra, N., Ngo, K., & Masters, R. S. (2011). A comparison of evaluation, time pressure, and multitasking as stressors of psychomotor operative performance. *Surgery, 149*(6), 776–782.

Price, G. R., & Hodge, D. C. (1976). *Detection of combat sounds by the Human Ear*. Human Engineering Lab Aberdeen Proving Ground Md.

Reason, J. (2000). Human error: Models and management. *BMJ, 320*(7237), 768–770.

Rafferty, L. A., Stanton, N. A., & Walker, G. H. (2013). Great expectations: A thematic anaylis of situation awareness in fratricide. *Safety Science, 56*(1), 63–71. doi:10.1016/j.ssci.2012.03.020

Rafferty, L., Stanton, N. A., & Walker, G. (2012). *The human factors of fratricide*. Farnham: Ashgate.

Richardson, M. J., & Johnston, L. (2005). Person recognition from dynamic events: The kinematic specification of individual identity walking style. *Journal of Nonverbal Behavior, 29*(1), 25–44.

Runeson, S., & Frykholm, G. (1981). Visual perception of lifted weight. *Perceptual and Motor Skills, 7*(4), 733–740.

Schneider, S., Christensen, A., Häußinger, F. B., Fallgatter, A. J., Giese, M. A., & Ehlis, A.-E. (2014). Show me how you walk and I will tell you how you feel: A functional near-infrared spectroscopy study on emotion perception based on human gait. *NeuroImage, 85*(1), 380–390.

Semple, K. (2008). US forces kill 6 Afghan police officers by mistake. *The New York Times*.

Shi, J., Weng, X., He, S., & Jiang, Y. (2010). Biological motion cues trigger reflexive attentional orienting. *Cognition, 117*(3), 348–354.

Shattuck, L. G., Graham, J. M., Merlo, J. L., & Hah, S. (2000). Cognitive integration: A study of how decision makers construct understanding in evolving contexts. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 44*(1), 116–119.

Steel, K. A., Adams, R. D., & Canning, C. G. (2006). Identifying runners as football teammates from 400 msec. video clips. *Perceptual and Motor Skills, 103*(3), 901–911.

Steel, K. A., Adams, R. D., & Canning, C. G. (2007). Identifying swimmers as water-polo or swim team-mates from visual displays of less than one second. *Journal of Sports Science, 25*(11), 1251–1258. doi: 10.1080/02640410601021721

Steel, K. A., Adams, R. D., & Canning, C. G. (2008). Junior football players' classification of runners as their teammates from 400-msec. video clips. *Perceptual and Motor Skills, 107*(1), 317–322.

Steel, K. A., Adams, R. D., Canning, C. G., & Eisenhuth, J. (2010). The Team-Mate Identification (TM-ID) test: Effect of participant and situation familiarity on response accuracy and latency. *International Journal of Sport Science and Coaching., 5*(2), 281–290. doi:10.1260/1747-9541.5.2.281

Steel, K. A., Adams, R. D., & Canning, C. G. (2012). Liking and response latency in teammate identification: Processing delays below conscious awareness? *Perceptual and Motor Skills, 114*(2), 519–526. doi:10.2466/05.07.21.pms.114.2.519-526

Steel, K. A., & Dogramaci, S. (2015). Does teammate recognition accuracy influence movement time in ice hockey? *International Journal of Kinesiology and Sports Science, 3*(2), 17–21.

Steel, K. A., & Eisenhuth, J. (2012). The Team-Mate Identification (TM-ID) test: A portable apparatus for collecting decision latencies for players in team invasion sports. *International Journal of Sport Science and Engineering, 6*(3), 159–164.

Steel, K. A., Ellem, E., & Baxter, D. (2015). The application of biological motion research: Biometrics, sport, and the military. *Psychonomic Bulletin and Review, 22*(1), 78–87.

Stevenage, S. V., Nixon, M. S., & Vince, K. (1999). Visual analysis of gait as a cue to identity. *Applied Cognitive Psychology, 13*(6), 513–526.

Stienen, B. M. C., & deGelder, B. (2011). Fear detection and visual awareness in perceiving bodily expressions. *Emotion, 11*(5), 1182–1189.

Swinford, S., & Farmer, B. (2012). "Friendly fire" kills British woman soldier in Afghanistan. *The Telegraph*.

Troje, N. F., Westhoff, C., & Lavrov, M. (2005). Person identification from biological motion: Effects of structural and kinematic cues. *Perception & Psychophysics, 67*(4), 667–675.

Tyrrell, R. A., Wood, J. M., Chaparro, A., Carberry, T. P., Chu, B. S., & Marszalek, R. P. (2009). Seeing pedestrians at night: Visual clutter does not mask biological motion. *Accident; Analysis and Prevention, 41*(3), 506–512.

Van Boxtel, J. J., & Lu, H. (2012). Signature movements lead to efficient search for threatening actions. *PloS One, 7*(5), e37085.

Vennum, T., Jr. (2007). *American Indian: Lacrosse—Little brother of war*. Baltimore: Johns Hopkins University Press.

Vine, S. J., Masters, R. S., McGrath, J. S., Bright, E., & Wilson, M. R. (2012). Cheating experience: Guiding novices to adopt the gaze strategies of experts expedites the learning of technical laparoscopic skills. *Surgery, 152*(1), 32–40.

Wade, N. (2006). *Before the dawn: Recovering the lost history of our ancestors*. London: Penguin Press.

Wilson, M. R., Vine, S. J., Bright, E., Masters, R. S., Defriend, D., & McGrath, J. S. (2011). Gaze training enhances laparoscopic technical skill acquisition and multi-tasking performance: A randomized, controlled study. *Surgical Endoscopy, 25*(12), 3731–3739.

Yam, C., Nixon, M. S., & Carter, J. N. (2004). Automated person recognition by walking and running via model based approaches. *Pattern Recognition, 37*(5), 1057–1072.

Zhu, F. F., Poolton, J. M., Wilson, M. R., Maxwell, J. P., & Masters, R. S. W. (2011). Neural co-activation as a yardstick of implicit motor learning and the propensity for conscious control of movement. *Biological Psychology, 87*(1), 66–73.