Visual Information Processing During Defensive Movement

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Abstract: The ability to avoid sudden appearance of moving stimuli and to protect the body from an attack is an essential function for humans, which can be used for defensive actions in various environments, including combative sports. Defensive actions involving goal-directed responses to visual stimuli presented in different parts of the viewing field commonly include movements either toward (TOWARD) or away from (AWAY) the actual stimulus. Responses determined in offensive actions do provide some insight to potential outcomes associated with defensive actions. In an effort to better understand defensive responses, which have received less attention in the literature than offensive movements regardless of their importance in combative situations, our current understanding of the underlying mechanisms of the information processing in defensive movement outlined, and directions for future research are suggested.

Index terms: Visual information processing, defensive movement, target eccentricity

1 INTRODUCTION

There are many tasks in which goal-directed responses to different sensory stimuli include movements either toward or away from the actual stimulus. Although plenty researchers study volitional responses toward a specific goal, few study movements away from a target. The latter is likely due to the lack of application for target avoidance during volitional movement; advancing toward a goal from what might be considered a position of offense is more common. However, blocking or withdrawing from sudden appearing or moving stimuli used in defensive movements are also basic functions of the motor system needed for task performance. Defensive movements are common tasks used for protection and are frequently used in certain sporting situations. Moreover, the findings from temporal responses to offensive movements do not necessarily generalize to sports situations which are dynamic and involve rapidly moving visual information where avoidance is patently necessary, as in the martial arts, for example.

2 DEFENSIVE RESPONSES

Defensive movements are spatially directed and can involve ducking or withdrawing from the direction of the stimulus or blocking an impending object with one part of the body [9], [17], [25]. For example, lifting the arm to protect the face from jabs, uppercuts and hooks occurs often in boxing. In combat sports, a player is continually faced with the problem of avoiding an opponent's attack which emerges at different and unpredictable locations. The player may initiate blocking or withdrawing actions or some combination of both to defend attacks from opponents.

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The block and withdrawal are two distinguishable responses to stimuli used for protection. Withdrawing or moving away from a stimulus serves to increase the distance between the defender and stimulus before impact in an attempt to avoid the approaching object and increase the amount of time available to prepare for sequential responsive movement [9]. The blocking component of defensive movements serves to deflect an impending impact. The instrument used to block, whether a segment or the body or external object, is positioned on the approach of a stimulus to protect an area (i.e. a goal) or another body part (i.e. the head) from stimulus contact. The blocking behavior reduces the distance between an approaching stimulus and effected target [9],[33] thus shortens the path of the stimulus. Since the goal of blocking actions involves target interception, they are placed in the TOWARD-response category and will be defined as movement toward an appearing or moving stimulus. In contrast, withdrawing actions are placed in the AWAY-response category and will be defined as movement away from a relevant stimulus. TOWARD and AWAY responses are assumed to build an interface between perception and behavior [8]. Many studies have distinguished between TOWARD and AWAY responses in laboratory settings by using different types of stimuli, although some researches use real world circumstances to elicit actual overt defensive responses [13],[17]. Some researchers interpret moving away from a target as an AWAY response and moving toward it as a TOWARD response [30], [38] whereas others use these actions in an opposite way (e.g. [7]). Although such opposition affects the definition of a TOWARD or AWAY movements, it also directs the use of TOWARD and AWAY responses despite the differences in focus, methodology and materials.

2.1 Defensive response: no visual field restrictions

The ability to orient the body to or away from the direction of suddenly appearing or moving stimuli and to protect the body from an attack may be a basic function of the motor system of humans [9], [17], [33]. Although the focus here involves avoiding certain stimuli through voluntary movement, the involuntary response of reflexes such as the startle reflex can and should not be ignored. Startle reflexes are short involuntary reflexive contractions elicited by abrupt, intense stimuli [19], [41]. Examples of intense stimuli include a loud noise, an unexpected tap on the shoulder and a sudden appearance of an object, while examples of the reflexive responses include eye blinks, increased muscle tension and vocalizations. A typical finding is that pleasant and unpleasant foreground stimuli can modulate the startle reflex. For example, when viewing two film clips depicting unpleasant events (fragment from a horror movie and a surgical operation), neutral events (non-argumentative conversation and a documentary) and pleasant events (fragments from romantic movies), participant's eye blink reflex which is measured from EMG activity of the orbicularis ocular muscle of the right eye varied. Unpleasant stimuli increased the amplitude of the startle response to loud acoustic stimuli and decreased the latency of eye blinks, whereas pleasant stimuli attenuated the amplitude and increased blink latency [19]. The latency of eye blinks, measured by EOG, was just the opposite during positive (smiling children or appetizing food) and negative (mutilated bodies) slide presentations, so that blink latency decreased for pleasant slides and increased for negative slides [37]. The negative slides were viewed for a longer period of time than neutral slides, thus were considered are highly potent in engaging visual attention, which explained this blink latency reversal. Studies of avoidance behaviors have overwhelmingly involved motivational systems that direct attention toward or away from relevant stimuli and give rise to corresponding emotional excitement that direct activity toward or away from relevant objects [12]. A number of experimental procedures have been devised to elicit individual approach and avoidance behaviors through manipulation of emotional stimuli such as incentives and threats. For example, RT was reduced for positive stimuli such as word "puppy" when participants had to perform approach movements by pulling a lever toward the body than for negative stimuli such as word "disgusting" when they had to perform avoidance movement by pushing the lever away [7]. Note these movements were relative to the participant rather than the location of the target as established in other studies. Participants, who were instructed to judge whether words were emotionally positive (e.g. peace) or negative (e.g. violence) by pressing one of two keys on a keyboard or do nothing if the word was neutral (e.g. slow), reacted faster to positive words when the word moved toward the participant than when it moved away [36], The opposite was true for RT to negative words in that RT decreased when the word move away from the participant and increased when it moved toward the participant. Overall, RT to positive words was 22 ms faster than RT to negative words. It is clear from the findings that emotional stimuli influence goal-directed behavior in that RT decreases with movements toward positive stimuli compared to stimuli associated with negative emotions.

2.2 Defensive response: central vs peripheral vision

The ability to avoid unwanted stimuli presented in various part of visual field is a critical aspect of adaptive behavior. Many investigations on the use of central and/or peripheral vision involve TOWARD-responses for offensive rather than defensive behaviors. In such studies evidence that RT may or may not differ according to stimulus eccentricity exists. The focus of this section is to review the influence of target eccentricity on defensive responses, an area in the literature that has received very little attention. Defensive responses to peripheral visual cues can involve voluntary or involuntary TOWARD and avoid responses. Seated participants playing a video game responded to suddenly appearing peripheral stimuli by rotating their heads toward or away from stimulus location [17]. RT for turning the head away from stimuli during avoidance movements was significantly shorter than those for orienting the head toward the target. In other study of defensive movement to looming visual stimuli standing participants fixated on a monitor located at 0° (i.e., straight ahead) with another monitor placed at 90° (i.e., near the left shoulder) during task and were asked to "play chicken" with an approaching ball that was projected on the computer-generated optical displays [34]. The goal was to move only at the last possible moment to dodge the path of the ball by leaning right or left for the monitor straight ahead or forward or back for the monitor to the left, movements that would let the person avoid ball interception for different paths. Four different contact times determined the moment at which the ball moving at four different speeds would have hit the participant if the person did not move. Initial responses to the 0.5 s and 1.0 s contact times did not occur until after impact, while responses to the 2 s and 4 s times occurred before impact. Response time in central looming was significantly faster than in the periphery. In a voluntary heading task, participants were asked to dodge a ball by flexing the torso without rotating their eyes or head when the ball approached from various eccentricities (0°, 20°, 40°, 60°, or 80°) at different velocities (1.0, 1.5, or 2.0 m/sec) (Li & Laurent, 2001). Results showed that initiation of torso flexion increased from 0° to 40° eccentricities, then decreased from 40° to 80° eccentricities, although participants successfully avoided the ball in all cases. Conflicting results may be to use of actual vs simulated stimuli.

2.3 Defensive response in different level of expert

Studies used to examine more realistic stimuli for initiation of defensive actions in sport-specific conditions for different levels of expertise also exist and offer insight to training effects on RT [27], [31], [39]. RTs were recorded in participants performing avoid or blocking movements in response to large screen recordings of karate athletes performing offensive movements [39]. Response accuracy was determined by experienced coaches to judge whether participant have successfully avoided or blocked the attack. Results showed that karate experts possessed faster RTs and higher accuracy than non-experts. In a similar projection setup, participants with and without expertise in karate were asked to decide as soon as possible whether the recorded offensive actions would be aimed at the upper or middle level of their body by pressing an appropriate key in this choice RT task [27]. The karate experts were slightly but significantly faster than those without training in responding to the video stimulus, suggesting RT training effects at least for tasks involving anticipation of the opponent's attack. Video-tapes were also used to introduce problem-solving situations simulating the natural setting of boxing [31]. Expert boxers had the same RT but were more accurate than intermediate and novice boxers when asked to move a joystick in a direction required to avoid or hit the movement in the video. Although these findings suggest that experts in combat sports are quicker at withdrawing and quicker and/or more accurate at blocking than those with less or no training, it is not completely clear that how these differences affect true outcomes of movement performance.

2. 4 Summary

Defensive behaviors allow researchers to compare TOWARD and AWAY responses to visual inputs. Defensive responses differ for the level of expertise so that athletes react faster and/or more accurate than nonathletes or those with little sporting experience. Effects of peripheral and central vision on defensive response times are limited and require further study to determine if or in what situations RT and MT for these responses will vary.

3 INFORMATION PROCESSING AND MOTOR PROGRAMMING DURING DEFENSIVE MOVEMENT

Rapid environmental changes in game and combat sports require flexible adaptation of behavior [15], [16]. Many athletes who successfully react in situations with rapid reaction sequences in sports and martial arts are able to execute motor responses by the perception of movement features embedded within the perceived movement sequences of sport partners or [2], [3], [4]. For example, boxers respond quickly to their opponent's fast actions to cope to the opponent's attack; they switch quickly from an intended action to a new more appropriate action when needed [16]. How does one explain the control used for such response to visually presented stimuli theoretically? Obviously, a person must be able to process the sensory input to some extent in order to respond to it. The information processing approach is used to assist in the explanation of such control. One of the most popular human performance theories or models is based on the fundamental notion that humans are processors of information much like a computer. Just as a computer requires input and must process the input in order to respond, the performance of several tasks requires information processing for producing the appropriate motor response to a given stimulus [22], [23]. Examine the situation where a boxer is defending opponent attacks with unexpected strokes. Although visual perception of the strokes and a response (blocking or withdrawing) seems to just happen, it is actually the end result of a complex process presented as a model that utilizes several issues previously presented. This is the information processing model. The information processing model has been used to explain performance of various task ranging from simple reaction to visual stimulus to complex problem solving sport situations[5], [31]. Here the three stage model is presented in terms of its application of defensive movements, a major theme in the current document. In defensive skills for combative sports or tasks the performer must recognize the opponent's attack strokes (the visual stimulus input) which can appear in the central or peripheral visual field. The ability to identify the stimulus, "recognize" the incoming stroke, occurs in the stimulus-identification stage or the first phase of information processing. Then during the response-selection stage (stage 2), the performer must select an appropriate response within the available options. The choice of whether to block the stroke or withdraw to avoid being hit by the attack is made. After determining an appropriate reaction, the performer must organize and initiate an appropriate response. Movement preparation and the initiation of the selected motor program are represented in the response-programming stage, the third stage of information processing. The response-programming stage is tightly coupled with level of expertise and development of motor programs which are a memory representation that stores information needed to perform an action. The key advantage of the motor program is that the problem of movement timing is simplified so that processing demands are reduced merely to predicting the moment of initiation, thereby reducing the computational burden on performers [35]. Thus, rather than organizing detailed control of all muscles required to block an attack, the performer only chooses how and possibly when to start the chosen blocking action. This model can explain the abilities to dodge a front jab and block a right hook. Each stage of the model is presented briefly below as it relates items presented in the current manuscript. Readers are referred elsewhere for more details on the information processing model [32].

3. 1 Stimulus identification

Sport situations requiring information processing are characterized by detecting stimulus or target in various forms of energy flowing through the environment, including light rays [3], [4]. The environmental changes which can be perceived from this energy flow over space and time are mostly used to support the goal-directed actions of the athlete. Remember, it is not only the type of stimulus that will influence transmission of the signal [28] and the time required to for stimulus identification, it also involves properties of the stimulus itself such as intensity [1] or complexity and abilities of the performer such as age [10]. An athlete's ability to quickly and accurately perceive relevant information will facilitate decision making and allow more time for preparation and organization of motor behavior [27], [31], [39].

3.2 Response selection and response programming

Selecting a response is required for the second stage of information processing and is used to make a decision based on identifying the information through environmental cues. In combat sports, an athlete must make rapid decisions about whether to block or avoid the opponent's attack based on information obtained from stimulus identification similar to that of choice RT tasks with opposing actions. Appropriate response selection is crucial to good performance [11], [40] thus increasing choice selection which also increases RT [14] of the response will have direct effects on response selection and indirectly affect response programming. The response-programming stage of the information processing approach is used to execute the response selected in the response-selection stage. Successful performance in block and withdrawal responses is at least somewhat dependent upon efficient and accurate execution of movement. Thus, practice effects have been consistently found to be the most important variable affecting organization and initiation of movement for response programming (Klapp, 1995). More complex situations require appropriate organization through a comparison with an internalized memory structure based on past experiences in similar situations. Selection of the appropriate motor program that is temporally consistent with the desired action will reduce the processing demands [35]. However, emphasizing accuracy which is well-known RT [6] and MT [29] of the response will have direct effects on response programming and defensive performance. It is not surprising that level of expertise is used to highlight the response-programming stage of information processing [21].

3.3 Summary

Information processing is a relatively simplistic model used to explain control of defensive actions. The three stages involve the use of sensory input, the selection of a response and organization and initiation of the response in order to complete movement performance. The use of a motor program, which is based on previous experience, helps reduce processing demands to produce more automated performances.

4. NEED FOR FUTURE RESEARCH

The ability to avoid sudden appearance of moving stimuli and to protect the body from an attack is an essential function for humans [9], [17], [33] which can be used for defensive actions in various environments, including combative sports. Although numerous researchers study TOWARD responses toward a specific stimulus, like that used for offensive actions, little is known about the TOWARD and AWAY responses used in defensive actions. Responses determined in offensive actions do provide some insight to potential outcomes associated with defensive actions. Although the limited research on defensive actions reveals similarities to those for offensive actions in that reaction time(RT) and movement time(MT) are highly dependent on the specified task, one must avoid the direct generalization of such information. The limited research of avoidance behaviors on response time does not allow for good comparisons between MT and RT for TOWARD and AWAY responses. This raises the question about how RT and MT in TOWARD response are different from the RT and MT in AWAY response, two responses commonly used for defensive actions (i.e. the block and withdrawal). Another issue involves the use of task inconsistency for studying TOWARD and AWAY responses. One must wonder whether using two opposing movements without considering directions are adequate for use in real life situations. To perform successful avoidance response, people must quickly and correctly perceive an object, which can be presented or approach from any part of the visual field. Presentation of stimuli in the central visual field is most common in research and the limited studies involving responses to eccentric visual cues reveal conflicting results. Few researches have investigated RT and MT in response to an object at various angles of eccentricity in avoid response even though avoidance behaviors are essential survival skills. Future research should study these avoid and TOWARD responses to different visual field stimuli to gain greater insight to defensive behaviors.

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