

SHORT COMMUNICATION: DIRECTING CHEERLEADER'S GAZE INFLUENCES MOTOR BEHAVIOUR IN SOMERSAULTS

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Abstract. Eye, head, and body movements are thought to be functionally coupled in the performance of complex skills, such as somersaults with and without twists (Davlin et al. 2001; von Laßberg et al. 2014). Directing the gaze to specific locations in the environment during the takeoff phase in somersaults could influence takeoff kinematics and, as a consequence, the subsequent flight phase. The goal of this study was to investigate the relationship between gaze direction during takeoff and the corresponding movement kinematics when performing backward somersaults in cheerleading. N = 11 cheerleaders performed standing backward somersaults in three experimental conditions (straight gaze direction, elevated gaze direction, depressed gaze direction). Results revealed that cheerleaders exhibited a larger hip angle during takeoff and longer flight duration of the somersaults when their gaze was elevated during the takeoff phase, thereby supporting the notion that a functional coupling seems to operate between gaze behaviour and motor behaviour in cheerleading. In daily practice, cheerleaders could try to focus their gaze on a point on the wall in front of them during the takeoff phase in somersaults in order to facilitate the development of a functional coupling between gaze behavior and motor behavior.

Key words: complex skill, whole-body rotation, visual perception

Introduction

It is thought that eye, head, and body movements are functionally coupled in the performance of complex skills (von Laßberg et al. 2014). Performers attempt to direct their gaze to task-relevant locations in the environment, and use that information when performing skills, such as somersaults with or without twists (Davlin et al. 2004; DeMers 1983). For instance, directing the gaze towards the floor during the second part of the flight phase of a backward somersault may help the performer anticipating the touchdown on the floor (Davlin et al. 2001; Luis and Tremblay 2008). Given the anticipatory and functional character of gaze behaviour, one could furthermore speculate that directing the gaze to specific locations in the environment during the takeoff phase could influence

takeoff kinematics and, as a consequence, the subsequent flight phase when performing a somersault. The goal of this study was to investigate the relationship between gaze direction during takeoff and the corresponding motor behaviour when performing backward somersaults in cheerleading.

Recent theoretical approaches argue that performers possess particular contingencies between sensory information and their corresponding motor actions with regard to the requirements of the task to be executed. It can be assumed that these contingencies are modality specific, and that they develop during skill acquisition (Davids et al. 2008; O'Regan and Noë 2001). Given, first, that a particular gaze behaviour is related to particular motor behaviour in light of the skill requirements, and second, that there is a (synergistic) intersegmental coupling when performing somersaults, one could assume that changes in gaze behaviour should lead to predictable changes in motor behaviour (von Laßberg et al. 2014).

Heinen et al. (2012) had for instance female gymnasts perform somersaults as a dismount on the uneven bars. Gymnasts gaze behaviour was triggered by means of a light spot during the downswing phase. The position of the light spot on the landing mat was systematically varied relative to gymnast's individual landing position. Kinematic parameters such as the hip angle during downswing or the landing position of the dismounts varied as a function of the position of the light spot. The authors concluded that the results indicated a functional relationship between gaze direction and corresponding motor behaviour during a backward somersault.

While it may be intuitive that directing gaze towards the landing area is functionally related to the landing position in somersault dismounts on the uneven bars, there may be other (functional) relationships when somersaults are performed under differing task requirements (Raab et al. 2009). For instance, when performing a standing backward somersault, the performer does not see the landing area during takeoff but rather directs one's gaze in front of him/her. Assuming that a synergistic intersegmental coupling is operant when performing somersaults (von Laßberg 2014), changes in gaze direction during takeoff should directly influence body posture during takeoff and thus lead to predictable changes in movement behaviour in subsequent movement phases. To examine this assumption, expert cheerleaders were asked to perform standing back somersault whilst their gaze direction was manipulated during the takeoff phase of the somersault. It was expected that changes in gaze direction would directly influence segmental coordination during the takeoff and should thus lead to changes in movement kinematics during the flight phase.

Methods

Participants

N = 11 cheerleaders ($M_{\text{age}} = 22$, $SD = 3$ years) participated in this study. They reported to have had regional and national experience such as participation in the regional and national championships. They were able to perform a backward somersault on the floor from an upright standing position. They furthermore reported an average training experience of six years, and they practiced in average for seven hours per week. It was decided to recruit experienced cheerleaders and study their movement behaviour in a natural setting (Vickers 2007). All participants were informed about the general purpose and the procedure of the study and gave their written consent prior to the study. The cheerleaders were, however, left uninformed about the specific purpose of the projected red dot (see Procedure Section). The experiment was carried out according to the universities' local ethical guidelines. All participating cheerleaders completed the experiment.

Task and Measures

The experimental task was to perform tucked backward somersaults from an upright standing position on a spring floor in three experimental conditions. A semitransparent screen was placed in front of the cheerleaders, allowing for rear projection by a laser projector, which in turn was placed in front of the screen (Figure 1).

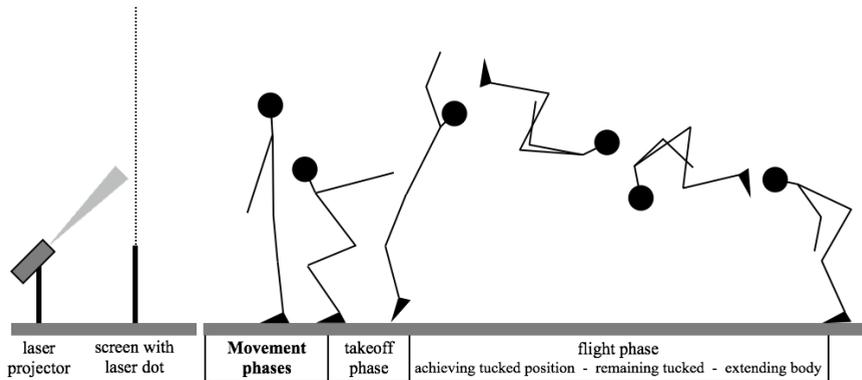


Figure 1. Stick-figure sequence and corresponding movement phases of the backward somersault, as well as instruments used in this experiment. Note: The red laser dot was projected on the semitransparent screen. The cheerleader was instructed to fixate his/her gaze on the red laser dot as long as possible during the takeoff phase of each somersault

Cheerleader's gaze direction was manipulated in three experimental conditions. The first experimental condition reflected cheerleader's straight gaze direction in upright stance on the spring floor. Therefore, a red laser dot was projected on the semitransparent screen at a height that matched cheerleader's individual eye-height when standing upright on the spring floor (Straight Gaze Condition, SC). In the second experimental condition, the position of the laser dot was elevated +5 degrees relative to cheerleader's individual eye-height in upright stance on the spring floor (Elevated Dot Condition, EC). In the third experimental condition, the position of the laser dot was depressed -5 degrees relative to cheerleader's individual eye-height in upright stance on the spring floor (Depressed Dot Condition, DC). When performing a somersault in one of the three experimental conditions, the cheerleader was instructed to direct her gaze to the red laser dot trying to maintain her gaze on the dot during the takeoff phase of the somersault. The cheerleader was furthermore instructed to perform a rule-adequate landing at the end of the somersault, stabilizing her landing for at least three seconds. A trained research assistant activated the projection of the red laser dot when the cheerleader got in front of the screen. The projection of the laser dot was manually deactivated when the cheerleader achieved the tucked body position during the somersault.

In order to assess kinematic parameters of the somersaults, a digital video camera was placed 15m away from and orthogonal to the movement direction of the cheerleader (sampling rate: 120 Hz, resolution: 640 × 480 pixels). The horizontal and vertical coordinates of the following body landmarks were tracked in a semi-automatic manner using the movement analysis software Simi Motion© version 8.5 (Simi Reality Motion Systems 2012): 1. left toe, 2. left ankle, 3. left knee, 4. left hip, 5. left shoulder, 6. left elbow, 7. left wrist, and 8. left ear. From the position data of the markers, nine time-discrete kinematic parameters were calculated, representing task-relevant criteria

(Arkaev and Suchilin 2004; Enoka 2002). The timing of the somersaults was defined by the relative durations of the movement phases: 1. takeoff phase, and 2. flight phase. Changes in body configuration were expressed by the values of the shoulder angle, the hip angle, and the angle between the trunk and the horizontal plane during takeoff from the floor, and when achieving the tucked position. Finally, landing performance was characterized by analyzing the absolute landing distance, defined as the orthogonal distance between the position of the toes during takeoff from the floor and during touchdown on the floor.

Procedure

The study was carried out in three phases. In the first phase, the participating cheerleader arrived at the gym and signed the informed consent form. The cheerleader was given a 15-minute warm-up phase to ensure that he/she was physically prepared. In the second phase, the participating cheerleader was asked to perform three tucked backward somersaults from a standing upright position on a spring floor in each of the three experimental conditions: 1. Straight Gaze Condition (SC), 2. Elevated Dot Condition (EC), 3. Depressed Dot Condition (DC), see Task and Measures Section, Figure 1). The performances of the somersaults were videotaped for later analyses. The three experimental conditions were presented in a random order for each cheerleader. There was no time pressure in this study and the cheerleader was allowed to take breaks as requested. In the third phase of the experiment the cheerleader was debriefed.

Data Analysis

A significance criterion of $\alpha = 5\%$ was defined for all reported results. In order to assess differences between the three experimental conditions, separate Wilcoxon Matched Pairs Tests were calculated between the straight gaze condition and the other two experimental conditions, taking the above listed kinematic parameters as dependent variables.

Results

Manipulating gaze direction revealed significant effects on kinematic parameters of the somersaults. In particular, cheerleaders exhibited a longer flight duration in the EC condition, $Z = 2.34$ ($p = 0.02$), a larger hip angle during takeoff in the EC condition, $Z = 2.08$ ($p = 0.04$), and a larger angle between the trunk and the horizontal in the EC condition, $Z = 2.11$ ($p = 0.03$), when compared to the SC condition. Taken together, the results show that cheerleaders appear to optimize their somersault performance in the EC condition. The results are presented in Table 1.

Table 1. Cheerleader's kinematic parameters (Means \pm Standard Errors) of the backward somersaults in the three experimental conditions, as well as as statistical parameters of the Wilcoxon Matched Pairs Tests

| Kinematic Parameters | Experimental Condition | | | Wilcoxon MP Test Statistic | | | |
|---------------------------|------------------------|--------------------|-------------------|----------------------------|------|-----------|-------|
| | Straight Gaze (SC) | Depressed dot (DC) | Elevated dot (EC) | SC vs. DC | | SC vs. EC | |
| | | | | Z | p | Z | p |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Timing of the somersaults | | | | | | | |
| Takeoff duration | 0.65 \pm 0.02 | 0.65 \pm 0.02 | 0.64 \pm 0.02 | 0.12 | 0.90 | 0.42 | 0.67 |
| Flight duration | 0.60 \pm 0.01 | 0.60 \pm 0.01 | 0.62 \pm 0.01 | 0.63 | 0.53 | 2.34 | 0.02* |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|------------|------------|------------|------|------|------|-------|
| Body configuration during takeoff | | | | | | | | |
| Hip angle | | 186.0 ±1.7 | 183.9 ±1.4 | 190.1 ±1.8 | 1.22 | 0.22 | 2.08 | 0.04* |
| Shoulder angle | | 145.5 ±2.8 | 142.2 ±3.8 | 144.4 ±3.1 | 1.54 | 0.12 | 0.82 | 0.41 |
| Trunk-horizontal angle | | 120.2 ±1.3 | 120.1 ±1.5 | 120.8 ±1.6 | 0.12 | 0.90 | 0.52 | 0.60 |
| Body configuration when achieving the tucked position | | | | | | | | |
| Hip Angle | | 65.9 ±1.7 | 65.5 ±1.7 | 64.9 ±1.8 | 0.31 | 0.76 | 1.16 | 0.25 |
| Shoulder angle | | 41.1 ±2.2 | 40.7 ±2.1 | 40.1 ±2.2 | 0.67 | 0.50 | 1.30 | 0.19 |
| Trunk-horizontal angle | | 184.6 ±2.7 | 183.3 ±2.5 | 189.2 ±2.9 | 0.67 | 0.50 | 2.11 | 0.03* |
| Landing performance | | | | | | | | |
| Landing distance | | 0.53 ±0.05 | 0.57 ±0.05 | 0.58 ±0.05 | 1.24 | 0.21 | 1.77 | 0.07 |

* significant difference between the corresponding experimental conditions.

Discussion and Conclusion

It becomes apparent that cheerleader's gaze behaviour is closely related to their motor behaviour when performing standing backward somersaults on the floor. Cheerleaders exhibited, for instance, larger hip angles during the takeoff phase of the somersaults, when they elevated their gaze direction, as compared to a straight gaze direction. A larger hip angle at takeoff indicates a more upright body position, which in turn may account for the longer flight duration that was found in the EC condition. Assuming that contingencies between (visual) information and their corresponding motor actions develop (and change) during skill acquisition (Davids et al. 2008; O'Regan and Noë 2001), the question remains, however, to which degree relationships between gaze direction and movement behavior may depend on, or co-vary with, cheerleader's expertise level. Current research in sports sciences and psychology highlights, for instance, expertise-dependent differences in gaze behavior in different sports (Mann et al. 2007). Additionally, it can be shown from research on everyday actions that gaze is directed towards locations that are relevant for a specific task (Land 2004). Evidence from research on complex skills in gymnastics finally shows that a well-coordinated coupling seems to operate between gaze direction and the movement of several body segments (von Laßberg et al. 2014). Based on the above-mentioned aspects, one could argue that in cheerleading a particular gaze behavior is associated with a particular (set of) motor skill(s), and experts direct their gaze in a way that best serves the execution of the task at hand (Raab et al. 2009).

There may, however, be a defined range in which a coupling between gaze and motor behavior is functional for the demands of the task at hand. For instance, in the current study, there were no influences on kinematic parameters when gaze direction was depressed as compared to a straight gaze direction. This could either indicate that gaze direction in the depressed dot condition was outside the functional range of the coupling between gaze direction and motor behaviour when performing standing backward somersaults, or even hampered the emergence of an optimal motor behaviour in somersaults. Consequently, the differences between the straight gaze condition and the elevated gaze condition could have been stronger if gaze direction would have been elevated to a larger degree. Thus, a subsequent study could explore the limits to which the coupling between gaze behaviour and motor behaviour is still functional for the execution of backward somersaults in cheerleading.

One common coaching technique in cheerleading as well as in sports with similar demands on motor coordination is to teach performers to focus on a point on the wall in front of them as long as possible during takeoff and during the first part of the flight phase (George 2010). It can be assumed that such a coaching technique facilitates the development of a functional coupling between gaze behaviour and motor behaviour in cheerleading.

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