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Recognizing fencing attacks from auditory and visual information: A comparison between expert fencers and novices

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ABSTRACT

Objective: The present study investigated the impact of audible and visual information for the prediction of attack movements in fencing, the raddoppio and the fleche.
Method: A temporal occlusion paradigm with visually (i.e. soundless videos), auditory (i.e. the audio track of the videos), and audio-visually (i.e. video with audio track) presented attack movements was used to investigate 15 experts' (5 women; *M* age = 17.2 years, age range = 15–21) and 17 novices' (15 women; *M* age = 23.4 years, age range = 19–30) performance in predicting fencing attacks.
Results: Results showed that the number of correct answers for all stimulus conditions increased for both groups the later a video was occluded. Moreover, experts outperformed novices in all stimulus conditions. Regarding auditory information, results indicated that neither group efficiently integrated the sounds of fencing steps with the visually provided information, however, experts were better able than novices to make use of auditory information if no visual information was provided and to filter out auditory information otherwise.
Conclusion: Future research might address the issue to what extent athletes might benefit from training interventions focusing on the use of auditory information.

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1. Introduction

An important aspect of social human interaction is to predict the intended action of another person. This ability is necessary to attune one's own actions to those of an interacting partner. Especially in fast running sport scenarios, early action anticipation is necessary to react quickly to an opponent and thus is an important component of skilled action performance. A fencer, for example, with outstanding *visual* abilities in anticipating attack techniques of opponent duelists, is particularly able to successfully parry attack movements. Interestingly, *auditory* information might also provide valuable cues for action anticipation in fencing: first, fencing as interactive combat sport is characterized by the weapons that make noises during attack and defense. Secondly, athletes move in a changing distance between each other on the *piste* (strip; specific fencing area) performing dynamic steps, jumps and attack movements that also cause noises on the ground. These auditory signals caused by a fencer's movements can inform the opponent if the athlete is starting a more or less rapid attack or stays in a passive defending position. Auditory information thus might be of special importance in fencing (Borysiuk & Waskiewicz, 2008).

The role of auditory information in an action-related context has been of increasing interest to researchers in recent years, even though the number of studies in this field is still very small compared to the number of studies investigating corresponding aspects of visual perception. Steenson and Rodger (2015) observed that most studies in this field focused on the processing of sound information, but disregarded its meaning and use in movement execution, an aspect that is paramount in a sports context. Indeed, studies on audio-based intervention in sports corroborated that auditory information is more pertinent than visual information with regards to rhythmic movement features, which is particularly important for precisely timed movements (Sors, Murgia, Santoro, & Agostini, 2015). Murgia and Galmonte (2015) have published a collection of articles focusing on the role of sound in motor perception and execution, in particular on the contribution of

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sound information to action representation, the saliency of auditory cues for recognizing movement features, and the question how auditory stimuli can affect movement production. Discrimination on the basis of action-based sound information between one's own compared to another's motor actions has been proved successful for different sports (Kennel et al., 2014; Murgia, Hohmann, Galmonte, Raab, & Agostini, 2012), and evidence from an EEG study supported these findings by reporting activation of an evaluation network for agent identification through action-related sound stimuli (Justen, Herbert, Werner, & Raab, 2014). Even though the rhythmic sound structure has been identified as relevant factor, self recognition does not depend on rhythmic features exclusively (Kennel et al., 2014).

Discriminating action features rather than agents on the basis of sound information has been the topic of a complementary line of studies. Sors and colleagues showed that amateur soccer players were able to evaluate the relative speed of penalty kicks on the basis of sound information (Sors, Murgia, Brunello, Prassel, & Agostini, 2015; Sors et al., 2017). Camponogara, Rodger, and Cesari (2016) showed that expert basketball players were better able to infer opponents' movement intentions from action-based sound more accurately than novices, by picking up action-specific movement information and using it to anticipate the opponent's future position. The authors suggest that the experts were better able than novices to pick up relevant kinematic features such as velocity, trajectory and position of deceptive movements through structural and transformational invariants of the movement sounds by directly mapping sound characteristics onto action intentions. These findings are supported by fMRI results showing that sports experts displayed specific activation in brain areas involved in action planning when passively listening to sounds from their own primary sports (Woods, Hernandez, Wagner, & Beilock, 2014).

With regard to *visual* information, it has been shown for many sports disciplines that skilled performers are better at predicting a forthcoming action than novices (Abernethy & Zawi, 2007; Aglioti, Cesari, Romani, & Urgesi, 2008; Müller & Abernethy, 2006; Sebanz & Shiffrar, 2009). A common method for investigating action anticipation in sport is the occlusion paradigm. In early occlusion experiments by Abernethy (1987), participants watched videos of sport scenes (e.g., badminton strokes) that stopped at different points in time (temporal occlusion). After the end of each video clip, participants were asked to predict the perceived action (e.g., the landing position of the badminton stroke). The general finding was that experts were better than novices at predicting a movement at an earlier point in time (Abernethy, 1990; Paull & Glencross, 1997; Renshaw & Fairweather, 2000; Williams, Ward, Knowles, & Smeeton, 2002).

Experts' anticipation superiority has also been found in fencing. Hagemann, Schorer, Canal-Bruland, Lotz, and Strauss (2010) conducted a comprehensive study to investigate whether or not eye movements of expert and advanced fencers and non-fencers while observing fencing attacks reflected their actual information pickup, using eye tracking in combination with temporal and spatial occlusion and cuing techniques. The task in these experiments was to predict the target regions of fencing attacks presented in video scenes. The results of the temporal occlusion experiment were in line with previous findings (e.g., Abernethy & Zawi, 2007), that is, better prediction performance was found in experts and advanced athletes than in non-athletes. Prediction performance was also better the later a video was occluded. In addition, eye tracking data showed that all groups predominantly fixated on the opponent's trunk and weapon. When the upper trunk and weapon were occluded (spatial occlusion), fencers' prediction performance decreased, indicating that foveal fixations (and not para-foveal or peripheral fixations) were used to extract important movement information. Summarizing the main findings, it can be stated that differences between experts, advanced fencers and novices were evident in all experimental conditions. Especially expert fencers could extract relevant movement information from temporally occluded video scenes, which is necessary for a successful prediction of the target regions of the attacks. As in this study (like in comparable studies using occlusion paradigms) video scenes were used without any sound, it is yet unclear if acoustic information might influence prediction performance in expert and non-expert fencers.

Auditory movement information has been suggested to be integrated with relevant information from other sensory modalities into a multimodal action representation in long-term memory (Land, Volchenkov, Bläsing, & Schack, 2013; Schack, 2004). A similar view has been brought forward by Rosenblum, Dias, and Dorsi (2017), who argue that information that is relevant to a given task is detected and processed independently of the modality through which it has been perceived. Furthermore, action representations result from action experience and motor learning, and they qualitatively differ between experts and novices (e.g., Bläsing, Güldenpenning, Koester, & Schack, 2015; Bläsing, Tenenbaum, & Schack, 2009). With regard to fencing, it has been claimed that, beyond visual and kinesthetic perceptual processes, the integration of sound might play an important role for the learning and development of fencing skills, for example, the ability to estimate the fencer's footwork rhythm to evaluate the distance to the fighting opponent (Borysiuk, 2008). Based on these considerations, it is investigated here whether or not auditory information improves the identification of fencing attack movements.

The present study investigates fencing attacks containing lunges (i.e. the *raddoppio*) and *fleche*. As not all readers might be familiar with these special techniques or fencing in general, the two attacks are described in the following and illustrated by Fig. 1.

A lunge is the most frequently used and practiced offensive attack in fencing. By lunging, the fencer can end an attack and score a point, or shorten the distance from the opponent very quickly (Molter, 2006). To lunge, the fencer straightens the front arm, lifts the front leg and straightens the rear leg, thereby producing an impulse that promotes a forward motion of the body center of mass. Subsequently, the fencer lands with the front leg in the lunging position: both arms straight, the weapon pointing at the opponent's trunk, and the rear arm in parallel to the rear leg. The upper body stays upright to enable an easy stand up back to fencing position (Nostini & Corsini, 1982). When performing a *raddoppio*, the fencer extends the described lunge, placing the rear foot directly behind the front one without lifting the hips or trunk. By pushing forward again, the fencer explosively performs another lunge in the described way, immediately reducing the distance from the opponent in one fluid movement.

The *fleche* is an explosive attack that is most commonly performed from a medium or long distance from the opponent. Starting from fencing position, the fencer straightens the arm and pushes the body center of mass quickly forward, towards the opponent. At the same time, the fencer crosses the front leg with the rear one and fully shifts the center of mass onto the front leg, thereby reaching full body extension (Nostini & Corsini, 1982). To catch residual drive, the athlete then runs past the opponent, thus interrupting the match. The fleche is most frequently used as surprising technique to overcome a large distance. Fencers need a highly distinctive springiness for explosively catapulting their center of mass forward as well as for catching the forward impulse. Due to the crossing of the legs, the fleche is only allowed in the disciplines *foil* and *epee* fencing (*sabre* fencers are by rules not allowed to cross the front and rear leg).

In both attack movements, the fencer intends to hit the target by

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