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“Look around while running!” Attentional focus effects in inexperienced runners

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ABSTRACT

While attentional focus effects on running economy have been shown in different settings for trained athletes, it is unclear how attentional instructions should be formulated to improve running economy for inexperienced runners. The present study was designed to fill this gap and test attentional focus effects in runners with little running experience. An experimental design was implemented and participants ran 4 × 6 min at a slow and fixed running pace with different attentional instructions for each block (video, breathing, running movement, no instruction), while oxygen consumption was measured continuously. The results showed best running economy (lowest oxygen consumption) in the video compared with the breathing and movement condition which goes in line with effects for trained runners. Therefore, inexperienced runners can also profit from directing their attention externally and commonly taught principles such as focusing on the coordination of breathing and stride patterns should be reconsidered.

1. Introduction

Runners have nearly endless possibilities what to think about when they are exercising: Major thought themes that emerged during a training run were for example pace and distance, pain and discomfort and the environment (Samson, Simpson, Kamphoff, & Langlier, 2015). An interesting question is whether a runner's focus of attention, that is what he/she concentrates on during the exercise, has an impact on running performance. Studies have shown that focusing externally on the environment during the execution of different endurance activities is beneficial for movement economy (Schücker, Anheier, Strauss, Hagemann, & Völker, 2013; Schücker, Hagemann, Strauss, & Völker, 2009; Schücker, Jedamski, Hagemann, & Vater, 2015). Running economy is defined as the rate of oxygen consumption (VO_2) at a given submaximal running velocity (Franch, Madsen, Djurhuus, & Pedersen, 1998; Jones & Carter, 2000; Saunders, Pyne, Telford, & Hawley, 2004). Running economy is strongly associated with running performance and can distinguish between good and poor runners within a group of running performers with similar VO_{2max} values (Moore, 2016). More specifically, participants in the experimental studies of Schücker and colleagues needed less oxygen to maintain the given intensity when focusing on a video compared to focusing on their movements or their breathing. It has to be taken into account, however, that these participants were all active or trained athletes, regularly exercising in their sports for several years, often with a focus on improving performance and participating in competitions. Therefore, it is unclear to what extend these results can be generalized to inexperienced runners who have recently started an endurance activity. Can they benefit from an external focus of attention in a similar way as trained athletes? It is not only possible that the attentional focus effect is different for this group, it might also be more difficult for inexperienced runners to adhere to provided attentional instructions (e.g. Okwumabua, Meyers, Schleser, & Cooke, 1983). Therefore, the present study was designed to yield recommendations regarding attentional focus instructions for runners who recently started a regular running routine.

1.1. Attentional focus in endurance tasks

The concept of attentional focus in the context of endurance performance has been defined in different ways. In 1977, Morgan and Pollock were the first to differentiate between two attentional strategies of marathon runners: An associative (task related) and a dissociative (task unrelated) attentional style. Twenty years later, Masters and Ogles (1998) wrote the first review paper regarding

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associative and dissociative strategies and highlight concerns about this terminology. They suggested that "terms such as cognitive strategies, attentional focus (external or internal), or distraction are appropriate" (p. 266). We follow their suggestions and in this paper we use the terms an internal (all bodily processes such as breathing, movement execution, heart rate, feelings of the muscles) vs. an external (distraction from physical activity) focus of attention. Masters and Ogles (1998) also pointed out that the term internal/external might not accurately reflect runner's cognitions and others have proposed a categorization along two dimensions, an associative-dissociative (task-relation) and an internal-external (body-relation) dimension (Stevinson & Biddle, 1999). Recently, a new working model of attentional focus in endurance activity suggested an extension of both dimensions (Brick, MacIntyre, & Campbell, 2014). According to this model, the internal associative dimension is subdivided into internal sensory monitoring (breathing, muscles soreness, fatigue, etc.) and active self-regulation (technique, cadence, pacing). External association is referred to as outward monitoring. As little empirical differences have been shown between internal dissociation (inward distraction, e.g. daydreaming) and external dissociation (outward distraction; e.g. environment), Brick et al. (2014) differentiated between active distraction (attention demanding voluntary distraction) and involuntary distraction (passive thoughts). This classification system serves well to categorize different kinds of attentional strategies during physical activities. It also summarizes and clusters previous studies that assessed the effects on different outcome measures. In order to make specific predictions about underlying mechanisms of attentional focus effects, Schücker, Knopf, Strauss, and Hagemann (2014) differentiated between an internal focus on physical sensations and an internal focus on automated processes and found that in line with their hypothesis only the latter was detrimental to movement economy. They assumed that focusing on automated processes disrupts their functioning, which is why these conditions were less economic.

All in all, the results of attentional focus effects on endurance performance are controversial (Brick et al., 2014; Lind, Welch, & Ekkekakis, 2009; Salmon, Hanneman, & Harwood, 2010). There is no agreement whether an internal/associative or external/dissociative focus of attention is more beneficial to performance. The inconsistent findings can be explained on the one hand by the broadness of the concept with different kinds of operationalization (e.g. internal focus on heart-beat, breathing, technique, physical sensations etc.; external focus on music, visual stimuli, video, external thoughts, etc.). On the other hand, studies are characterized by a range of different outcome measures (e.g. speed, duration, perceived effort, physiological measures). For outcome measures such as running speed or duration, motivation and willingness to make an effort can be seen as confounding variables which is why Schücker et al. (2009) introduced the physiological outcome parameter of running economy as a more objective variable. In her review on biomechanical factors influencing running economy, Moore (2016) concludes that attempts to instruct an optimal running technique did not result in improved running economy. This is why one could assume that the motivation to run more economically is not sufficient to increase economy. In a study from the domain of music, Terry, Karageorghis, Saha, and D'Auria (2012) showed that running economy was better when listening to music, however, there was no difference between motivational and non-motivational music, which could also be interpreted as evidence that motivation does not influence running economy. Schücker et al. (2009) were successful in showing focus effects on running economy. Therefore, for the background of the present study we focus on studies that have used more objective physiological outcome measures that have the potential to reveal a more consistent pattern of effects and provide a link between cognitive variables (i.e. focus of attention) and physiology.

1.2. Attentional focus and efficiency measures

For discrete motor tasks, a growing number of studies from the field of motor control and learning[1] included muscle activation (electromyographic activity; EMG) as the dependent measure (see e.g. Wulf, 2013 for an overview). The majority of these findings reveal that EMG activity is reduced when focusing externally compared to focusing attention internally on movement execution (Greig & Marchant, 2014; Lohse, Sherwood, & Healy, 2010; Vance, Wulf, Töllner, McNevin, & Mercer, 2004; Wulf, Dufek, Lozano, & Pettigrew, 2010; Zachry, Wulf, Mercer, & Bezodis, 2005). Accordingly, this can be seen as improved efficiency when directing attention externally on the movement effect.

Applying this to the field of endurance performance, it is the physiological performance measure of movement economy that has been used to assess attentional focus effects in endurance tasks. In running, it has been shown that higher EMG activity requires more VO_2 and therefore leads to lower economy (Kyröläinen, Belli, & Komi, 2001). In her review Moore (2016) concludes that greater muscle activation is detrimental to running economy. Although early studies do not show effects of focus of attention on this outcome measure (Hatfield et al., 1992; Morgan, Horstman, Cymerman, & Stokes, 1983), more recent studies mirror those on EMG activity in discrete motor tasks: An external focus of attention leads to improved movement economy (lower VO_2) compared with an internal focus during running at moderate intensity (Schücker et al., 2009), running at high intensity (Schücker et al., 2013), or at moderate intensity in rowing (Schücker et al., 2015). In the first of this series of studies, participants ran three times 10 min on a treadmill at an individually predetermined sub-maximal intensity of 75% of VO_{2max} (Schücker et al., 2009). For each of the 10 min running blocks they were instructed to focus their attention on either their breathing (internal), their running movement (internal), or on a video displayed in front of them (external). Oxygen consumption was assessed continuously throughout the running bouts. The results revealed best economy in the video condition followed by the movement condition and the least economic running for the breathing condition. Despite changes in oxygen consumption, ratings of perceived exertion were not affected, which means that the physiological effects did not go in line with subjective ratings (Schücker et al., 2013, 2014). The theoretical explanation for improved economy during an internal over an external focus can be based on the constrained-action hypothesis (Wulf, McNevin, & Shea, 2001). According to this hypothesis automatic control processes are hindered when focusing internally on movement execution which leads to disturbed and less efficient movement coordination (Wulf, 2007; Wulf et al., 2001). Therefore, internal foci during running that relate to automated processes (such as running movement or breathing) led to lower economy than an external focus where automatic processes were able to run off undisturbed. Schücker et al. (2014) also used this framework to predict differences within an internal focus. They showed that only those internal foci that relate to automated processes were detrimental to economy while focusing on the general feeling of the body was not.

However, the fact that different studies revealed an impact of attentional focus on running economy (e.g. Schücker et al., 2009,

[1] These studies look predominantly at discrete motor tasks and define focus of attention narrow and consistently with an internal focus on movement execution and an external focus on the effects of the movements.

2013) should be regarded in light of the complexity of attentional focus and performance outcomes. On the one hand, adopting just one focus for a longer period of time does not account for a more transient and dynamic adoption of attentional foci which is likely to occur during usual running and racing. An external focus might be more adaptive during some points (e.g. distracting from discomfort, letting automated processes run-off undisturbed) and an internal focus on physical sensations (e.g. to optimally adapt pacing) at other points. Furthermore, those studies have been conducted in laboratories and effects in actual racing when exercising at maximum intensity while freely selecting the pace still need to be examined. Keeping in mind that the classic study by Morgan and Pollock (1977) used a very different methodological approach by assessing attentional strategies of elite marathon runners in interviews, it is notable that it points to the importance of the ability for elite runners to focus internally on physical sensations in order to adjust running pace.

Added to this, it has to be noted, however, that all studies used active/trained participants with several years of experience in their respective endurance task. There are two further studies that included running economy as their outcome measure, but those have yielded different results: While Ziv, Meckel, Lidor, and Rotstein (2012) did not find differences between an internal (movement) and an external (video) condition on running economy, Neumann and Piercy (2013) found best running economy in the movement condition compared with breathing, or distance travelled. When comparing these results to those of Schücker and colleagues it is important to take a few methodological differences into account. Ziv et al. (2012) on the one hand did not examine experienced runners but basketball players who ran on a treadmill and furthermore used a different video (a basketball game instead of a running course). Therefore, both, participant characteristics and the implementation of the external focus could have influenced the results. Neumann and Piercy (2013) used a sample of recreational exercisers who were more inexperienced in running and had a lower fitness level than Schücker et al.'s participants. Accordingly, experience level of participants with the endurance task is a potential moderating factor of the attentional focus effect on running economy.

1.3. Attentional focus effects at early stages of learning

In the motor learning domain, the concepts of internal and external focus of attention have been widely researched focusing mainly on discrete motor tasks. The work by Wulf shows that an external focus of attention is not only beneficial for performance but also for learning new motor tasks (Wulf, 2007, 2013). It has to be noted, however, that the terminology in this area carries a different meaning, especially regarding the external focus which in this area means to focus on the effects of the movement which is different to a distraction focus in endurance activities. Therefore, it has to be noted, that the external focus as conceptualized by Wulf is a task related focus, relevant for successful performance outcomes. Bearing these different meanings in mind, it is still worth noting, that even at early stages of motor learning, directing the focus away from the body towards the effects of the movement has been of advantage for learning new skills. This was initially shown for a ski-simulator and a stabilometer balancing task (Wulf, Höß, & Prinz, 1998), for golf (Wulf & Su, 2007; Wulf, Lauterbach, & Toole, 1999), and as well for numerous other motor tasks (for an overview see Wulf, 2007, 2013).

Another line of research looked at a skill related focus of attention vs. an extraneous focus of attention (e.g. on stimuli in the environment) using dual task research designs instead of instructions. Beilock, Carr, MacMahon, and Starkes (2002) revealed that for novices a skill related dual task (monitoring the foot in soccer dribbling) was more beneficial than an extraneous dual task. Castaneda and Gray (2007) showed similar results for inexperienced baseball players who benefited from focusing attention to the step-by-step execution of the movement. However, how these findings hold for endurance tasks where movements are carried out in an ongoing, rhythmical way over a countless number of cycles has not yet been examined. Even at early stages of learning the repetitive movements in these tasks have been executed may times and a focus on all single steps of movement execution (e.g. in running the forward movement of the legs, placing the foot on the ground, lifting off, coordination with arm movements, etc.) might not be necessary.

1.4. Attentional and metabolic demands during the acquisition of endurance tasks

Theories of skill acquisition hold that the acquisition of motor skills runs through different phases of learning (Anderson, 1982; Fitts & Posner, 1967; Schneider & Fisk, 1983). For motor tasks this means that initially attention is needed to control movement execution in a step-by-step manner. Over the course of practice procedural knowledge develops and movement execution runs off in a more automated way (Beilock et al., 2002). Accordingly, well-learned motor skills run off automatically and need little conscious control. Besides attentional demands necessary to execute the movement, especially in complex energy demanding physical activities, learning and practice effects can also be observed on the level of physiological efficiency. Based on the assumption of the principle of optimization of metabolic efficiency (Sparrow & Newell, 1998), a range of different studies showed decreasing metabolic energy costs in the learning process of for example slalom skiing (Almasbakk, Whiting, & Helgerud, 2001), rowing (Lay, Sparrow, Hughes, & Odwyer, 2002), complex inter-limb coordination tasks (Lay, Sparrow, & Odwyer, 2005), walking on a split-belt treadmill (Finley, Bastian, & Gottschall, 2013), or race walking (Majed, Heugas, Chamon, & Siegler, 2012). However, these effects have not yet been linked to effects of attentional focusing.

1.5. The present study

Common instructions used by running coaches for beginners often relate to the breathing process, the movement execution, or the coordination of breathing and stride patterns (e.g. Luff, n.d.) – the question is whether these instructions are actually beneficial in terms of movement economy. To address this issue, the aim of this study was to assess which kind of attentional focus leads to most economic running for inexperienced runners. In order to follow a physical activity program with endurance sports, advice on where to focus one's attention might prove helpful, as more economic running could also be perceived less effortful. In addition, due to a lesser draw on physiological resources a good attentional focus strategy could help to run over longer time periods. Based on assumptions of the constrained action hypothesis (Wulf et al., 2001) an internal focus on automated processes is supposed to lead to worse movement economy than an external focus, which is in line with previous running studies (Schücker et al., 2009, 2013). For the present study, we assume that even for inexperienced runners an external focus of attention is advantageous compared to an internal focus on the movement or the breathing process (both highly automated). Even though evidence in other motor tasks suggests that novices benefit from focusing step-by-step on the movement (Beilock et al., 2002), running is not a completely new task and even beginners have at least some experience with running.

2. Method

2.1. Participants

A total of thirty participants took part in the study (10 male; 20 female). Even though previous studies showed at least large effect sizes and ranged to very large effects (e.g. $\eta^2_p = 0.56$ in Schücker et al., 2009; $\eta^2_p = 0.18$ in Schücker et al., 2013; $\eta^2_p = 0.29$ in Schücker et al., 2014) sample size estimations were computed with medium effect sizes to account for the possibility of smaller effects in this sample of inexperienced runners. G*Power 3.1 analysis (input parameters: $f = 0.25$, $\alpha = 0.05$, $1-\beta = 0.80$, 1 group, 4 measurements, $r_{\text{repeated measures}} = 0.50$, $\varepsilon = 1$) yielded required $n = 24$. Participants' mean age was 33.9 ($SD = 12.84$) years. Twenty-one of the participants reported prior running experience and indicated that they ran on average $M = 1.46$ h/week ($SD = 1.08$) and 20 of them reported covering a distance of $M = 9.1$ km/week ($SD = 7.5$). As the study focused on inexperienced runners (as compared to trained/active runners in other studies), inclusion criteria were to be fit enough to run 30 min at 6,5 km/h (a very slow pace but running rather than walking). Exclusion criteria were to have prolonged running experience. Participants were recruited from local clubs who provide guided running programmes (with aim to run 30 or 60 min constantly at the end of the programme) and through advertisement in fitness studios. All participants were informed about the procedure and measurements and provided written informed consent before participation. The ethics committee of the faculty approved the study protocol.

2.2. Apparatus

All measurements were carried out in the human movement laboratory on a h/p/cosmos pulsar 3 p treadmill (h/p/cosmos sports & medical GmbH). Oxygen uptake (VO_2) was measured by a METAMAX cardiopulmonary exercise testing system (Cortex Biophysik GmbH), calibrated on each day of testing according to the manufacturer's instructions. To capture gas exchange, participants wore a breathing mask throughout the run. Alongside VO_2 a range of further respiratory parameters was assessed by the METAMAX system (respiratory rate, respiratory volume, ventilation rate, respiratory quotient) for further exploration of breathing patterns. Heart rate was assessed by a chest belt (Polar Electro), which transmitted the signal to the METAMAX software.

2.3. Procedure

Upon arrival at the lab participants were informed about the testing protocol, and then equipped with the METAMAX system including the breathing mask, the chest belt and a safety belt for the treadmill. Following a 5 min warm up (3 min 4.5 km/h, 2 min 5.5 km/h) they ran 4×6 min at 6,5 km/h with 2 min rest in between. The speed was chosen because it represents a slow speed, which is just a little bit faster than walking and it was assumed that participants who have little running experience would be able to complete the 4×6 min. Furthermore, it is similar to the speed used in another study using inexperienced runners, which obtained a mean speed of 6,7 km/h (Neumann & Piercy, 2013). However, in the present study all participants ran at the same speed, it was not adjusted individually and participants were informed about the speed in advance. A video showing a running course from the perspective of a runner at about 6,5 km/h was displayed during all conditions on a big screen (displayed size of the video 192×315 cm) positioned 50 cm in front of the treadmill. This was done to give participants a more natural feeling of running in an outside environment. For each of the 6 min running intervals participants received different attentional instructions. The order of the four attentional conditions was counterbalanced (24 different sequences) to avoid order effects.

2.3.1. Attentional instructions

In this experiment two internal, one external and one control condition were implemented. In the *internal breathing* condition participants were asked to direct attention to their breathing and more specifically to breathing in and out; in the *internal movement* condition participants were asked to direct their attention to the running movement and more specifically to focus on their feet and forward movement of the legs (see Schücker et al., 2009, 2014). In the *external* condition participants had to focus on the video and the shown running course. In the *control* condition no specific focus was provided and participants were told they could run how they usually do. In each condition the instructions were repeated every 30 s via loudspeakers to remind participants of their respective focus. This methodological approach has been successfully used in previous studies (Schücker et al., 2014). In the 2 min breaks following each of the 6 min running intervals, participants were asked for how much percentage of time they were able to actually implement the instructed condition and furthermore asked where specifically they focused if their attention had shifted. This question served as a subjective manipulation check measure. After the manipulation check, participants were also asked to indicate their perceived exertion on the Borg-Scale ranging from 6 to 20 (Borg, 1998).

2.4. Statistical analyses

Data were analysed with IBM SPSS statistics 22. One factorial (attention, 4 conditions) repeated measures ANOVAs were computed for the dependent variables (running economy, further respiratory parameters, heart rate and RPE). To analyse overall differences between the attention conditions, mean values of oxygen consumption from minutes 2–6 were calculated, excluding a short 1 min warm-up at the start of each condition where oxygen values increased rapidly and participants got used to the new instructions. Fig. 1 shows the course of oxygen consumption for the whole 6 min and the relevant part used for the statistical analysis. To test for specific predictions regarding the conditions, contrasts were calculated, using the external condition as the reference category to test for the predicted differences to both internal conditions. For effect sizes, η^2_p are reported. Greenhouse-Geisser adjustments of degrees of freedom were used for violations of sphericity assumptions.

3. Results

3.1. Manipulation check

First we report the subjective manipulation check values for the different conditions: Participants were best able to follow the video instructions and indicated that they concentrated on the video for $M = 84.43\%$ ($SD = 15.1$) of time, followed by the breathing instruction $M = 75.5\%$ ($SD = 18.86$) and the running movement instruction with $M = 66.67\%$ ($SD = 22.1$). It is obvious that not all instructions were implemented equally well, at least in terms of subjective ratings. We also explored where participants focused in the control condition. Participants indicated all aspects they focused on and the corresponding percentage of time. $N = 26$ participants named the video ($M = 50.38\%$, $SD = 29.46$), $n = 11$ participants named breathing ($M = 49.09\%$, $SD = 26.25$) and $n = 12$ participants named the running movement ($M = 28.75\%$, $SD = 19.79$). $N = 21$ participants indicated other things such as

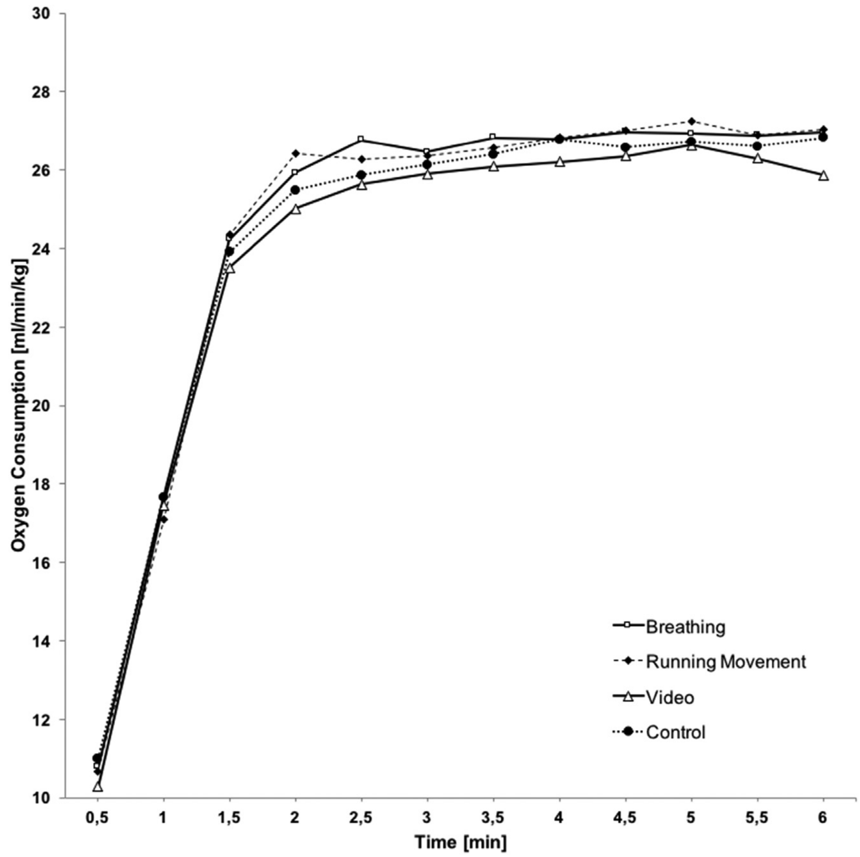

Fig. 1. Course of oxygen consumption for the experimental conditions. Note that values for the first minute were excluded from statistical analysis.

unrelated thoughts (37.14%, $SD = 23.27$). Overall focus on the control conditions seemed to be quite heterogeneous including external as well as internal aspects.

3.2. Running economy

The repeated measures ANOVA revealed a significant difference between the four attention conditions, F (2.22, 64.38) = 3.2, $p = 0.04$, $\eta^2_p = 0.099$. Mean oxygen consumption was $M = 25.75$ ml/min/kg ($SD = 1.96$) for *video*, $M = 26.47$ ml/min/kg ($SD = 1.92$) for *breathing*, $M = 26.49$ ml/min/kg ($SD = 2.48$) for *running movement*, and $M = 26.13$ ml/min/kg ($SD = 2.18$) for the *control* condition. The contrast analysis revealed that both internal conditions were significantly different from the external condition: Contrast breathing - external $F(1, 29) = 7.71$, $p = 0.01$, $\eta^2_p = 0.21$, contrast running movement – external $F(1, 29) = 4.8$, $p = 0.04$, $\eta^2_p = 0.14$. The control condition was not different from the external condition, $F(1, 29) = 2.08$, $p = 0.16$, $\eta^2_p = 0.07$.

3.3. Further respiratory parameters

For a more differentiated picture of the breathing pattern, descriptive and ANOVA results for each of the further parameters assessed by the spiroergometric system (breathing rate, respiratory volume, ventilation rate, respiratory quotient) are displayed in Table 1. It is interesting to note that a focus on the breathing process did not only lead to highest VO_2 but also to a changed pattern with slower breathing and deeper breaths.

3.4. Heart rate and RPE

Average heart rate (again excluding min 1) also differed between the attentional conditions, F (3, 87) = 3.19, $p = 0.028$, $\eta^2_p = 0.099$. Heart rate was lowest in the video condition ($M = 142.65$, $SD = 14.52$) and highest in the running movement condition ($M = 146.89$, $SD = 15.91$), breathing ($M = 143.01$, $SD = 13.96$) and control ($M = 143.70$, $SD = 15.02$) were in between. The contrast analysis revealed that only the internal running movement condition was significantly different from the external condition, $F(1, 29) = 7.71$, $p = 0.01$, $\eta^2_p = 0.21$. Neither the internal breathing condition $F(1, 29) = 0.06$, $p = 0.81$, nor the control condition $F(1, 29) = 0.52$, $p = 0.48$, $\eta^2_p = 0.02$, were different from the external condition. There were no differences in ratings of perceived exertion between the conditions, F (3, 87) = 0.882, $p = 0.45$ and absolute values were in the moderate range between RPE = 11.87 (video), RPE = 11.97 (control), RPE = 12.03 (running movement) and RPE = 12.30 (breathing) on the 6–20 scale.

4. Discussion

The aim of the present study was to assess which attentional instructions are most beneficial for inexperienced runners in order to optimize their movement economy. While previous studies have shown positive effects of an external focus of attention on running economy in trained runners (e.g. Schücker et al., 2009, 2013), the effects for inexperienced runners were unclear and showed different effects (e.g. Neumann & Piercy, 2013). The results of the present study reveal that instructions where to focus ones' attention while running also affect running economy in inexperienced

Table 1
Respiratory parameters.

	Movement execution	Breathing	Video	Control	*p*	Partial η^2
Respiratory rate (breath/min)	31.33 (6.09)	25.74 (5.44)	31.27 (6.3)	31.08 (5.96)	0.000	0.47
Respiratory volume (l/breath)	1.78 (0.36)	2.04 (0.56)	1.75 (0.36)	1.76 (0.41)	0.000	0.47
Ventilation rate (l/min)	54.49 (12.26)	50.70 (10.79)	53.97 (14.11)	53.29 (14.11)	0.001	0.2
Respiratory quotient[a] (−)	0.92 (0.05)	0.91 (0.05)	0.93 (0.08)	0.92 (0.05)	0.08	0.086

Note. Mean values (*SD*) for the last 5 min of each 6 min block (excluding the starting phase). P - values and effect sizes based on repeated measures ANOVA with the factor attention condition.
[a] Respiratory quotient calculated from the ratio CO_2 produced/O_2 consumed.

runners in a similar way as in more experienced runners. In the present study inexperienced runners ran most economically when focusing externally (video) instead of internally on either movement execution or breathing. Thus, the effects found for experienced runners can be replicated with a different sample of runners with lower experience level. However, the effect in the present study was not as big as in previous studies. Comparing effect size measures Schücker et al. (2009) reported $\eta^2_p = 0.56$, whereas the present study found $\eta^2_p = 0.099$ for the overall ANOVA. A possible explanation could be that participants in the present study were less well able to implement the instructions as can be seen e.g. in the reported manipulation check values which were lower in the present study (video about 5% lower, breathing about 10% lower and movement more than 10% lower) than reported in the study with trained runners by Schücker et al. (2009). A closer look at the manipulation check data reveals what else participants focused on during each of the experimental conditions: In the video condition $n = 9$ participants indicated that they also had unrelated thoughts, $n = 9$ indicated focusing on the experimental setup (including breathing mask and treadmill), further categories were breathing ($n = 6$) and movement ($n = 4$). In the movement condition $n = 17$ named the video, $n = 10$ had unrelated thoughts, $n = 9$ focused on breathing and $n = 9$ on the experimental setup. Finally, in the breathing condition most participants also indicated the video ($n = 20$), the set-up ($n = 10$), other unrelated thoughts ($n = 6$) or focused on movement ($n = 2$). A methodological difference to Schücker et al. (2009) was that the video was playing in all conditions on a large screen and it is evident that in the non-video conditions participants were to some extent also focusing on the video. Although this could have potentially made it harder to adhere to the breathing and movement conditions, this increases ecological validity of the present study. The environment is kept the same, only the attentional instructions change. A video of a running course from the perspective of a runner (at approximately the same speed as the treadmill) further facilitates a more natural running feeling: In outdoor running the environment changes due to forward running movement, while in indoor running the runner's location is the same. If the video had only played in the external condition, then this condition might have felt more natural than the others which might have confounded the results. Therefore, this set-up can be seen as an improvement compared to the set-up by Schücker et al. (2009) and was also implemented by Schücker et al. (2013, 2015). Added to this, when looking at inexperienced runners, it is important to take into account that they (in contrast to trained and regular runners) might need more attentional resources to execute the movement and will need further attentional resources to adopt different kinds of attentional foci (e.g. Beilock et al., 2002; Fitts & Posner, 1967). Possibly, this could be one reason why the attentional focus effect is smaller than for trained runners. Another reason might be that the running movement of these inexperienced runners has been less automated and it can be assumed that the detrimental effects of focusing attention on automated processes will be larger with increasing automation. The work by Beilock et al. (2002) suggests that at the beginning of the learning process it might well be helpful to focus on the step-by-step execution of the movement. Even though this study used inexperienced runners, they already had some running experience and running in general is not a completely new movement (like learning to throw a dart/basketball free throw/golf) which has never been done before and therefore a certain degree of automaticity had already been developed.

The present results somewhat contradict Neumann and Piercy's (2013) results who found best running economy in a sample of recreational exercisers in a movement compared with a breathing condition and a focus on distance travelled. What should be noted in this regard is that the attentional instructions are not fully comparable. The external focus on distance travelled might not have been as useful to runners than a focus on a video displaying the running course from the perspective of a runner. This methodological difference could potentially explain the different results.

The present results also replicate the additional findings on changes in the breathing pattern: When focusing on breathing, large changes in breathing rate (lower) and respiratory volume (higher) emerged also in the present study. Therefore, this result seems to be quite robust as it has now been shown in different studies including active runners and different intensities (Schücker et al., 2009, 2013, 2014), and now also with a sample with little running experience. Furthermore, the elevated heart rate levels in the running movement condition were also reported by Schücker et al. (2014).

A limitation of the present study could be seen in the implementation of the conditions: The manipulation check showed that not all instructions were implemented equally well and especially focusing on the running movement seemed to be difficult. Some participants ($n = 5$) even indicated they very only able to follow instructions for less than 50% of time.[2]

Therefore, it is reasonable to assume that participants with lower experience have more difficulty to follow attentional instructions and their focus shifted more frequently to other aspects. However, this is what would be expected when running for a longer duration, it is not very realistic to focus on just one thing for several minutes and even if attentional focus was not directed to the prescribed aspect for the whole time, it still made a difference in terms of economy. Lastly, participants in the present study had little running experience but were not total novices. To look at effects for complete novices a different experimental design would be required as participants would initially have to train to be able to run for a given time (e.g. 4 × 6 min), possibly in a longitudinal design. Furthermore, even though the sample was a little

[2] We considered only using those participants who indicated to follow the instructions for at least 50% of time in the analysis which would exclude $n = 5$ participants. However, we decided against this criterion for the following two reasons: First, the main results did not change if we included or excluded those 5 participants and second, it was a subjective retrospective rating which we feel is not a very reliable cut-off score.

heterogeneous (but all within a low level), all runners had the same very slow speed (6.5 km/h) due to ecological reasons. Therefore, for some participants the intensity might have felt different than for others and the generalization of the results is limited. As previous research showed that the attentional focus effect is evident for moderate as well as for high intensities the fact that the speed was the same should not have seriously influenced the direction of the results. An alternative approach might have been to allow a self-selected pace in order to receive a broader picture and look at the impact of attentional focus on running economy at different individual speeds.

It should be noted, that the control condition was not different to the external condition. This might suggest, that the internal focus conditions were more unnatural than the external one. This is why it is difficult to say that inexperienced runners should focus differently to what they normally do. However, focus in the control condition was quite varied including internal as well as external things (e.g. the video, breathing, the running movement as well as unrelated thoughts). These aspects were all averaged in the control condition and might have therefore not shown differences to the external condition. Furthermore, the external condition with a video of a running track was task relevant and it remains to be investigated, how other external conditions that are unrelated to the task (e.g. music) affect economy. If the explanation for the findings is seen only in the fact that internal conditions hindered automated processes, then any kind of distraction should result in similar effects. However, this should be tested in future research. In all, if we were to give recommendations where inexperienced runners should direct their attention while running, given the present results, we would advocate an external focus. Nonetheless, one should bear in mind that this recommendation is likely an oversimplification of the relationship of attentional focus effects and endurance performance. As said earlier, shifts in attentional focus when running for a longer period of time are frequent and a more dynamic and adaptive focus corresponding to demands of the situation and the performer (e.g. intensity and experience level) might be more appropriate than concentrating on one single aspect. Still, if running economy can be increased just a little bit by focusing externally at some points throughout a run, maybe beginning runners could run longer at a given intensity.

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