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Representing reality: Investigating the perception-action couplings of expert soccer Goalkeepers under representative constraints

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A significant assumption in the psychological sciences has been that expert decision making implies the existence of a centralized control system responsible for behaviour (Schmidt, 1975), advocating for the processing of information via the production of internal representations. This approach often studies the individual mechanisms of an action in isolation from contextual variables (Renshaw et al., 2018), consequently failing to reproduce the complex performance environment.

Despite a lack of situational context, laboratory studies have provided the central foundations to build perceptual research. However, the importance of context, as asserted by Brunswik (1955), has led to the furthering of representative design as a key concept for experimental study.

As technologies develop, and epistemologies shift, researchers have pursued more dynamic and representative experimental conditions in sport research, particularly with the study of visual gaze. Dicks et al. (2010) examined responses in a soccer penalty kick task, showing that decontextualized actions caused goalkeepers to use alternate gaze strategies to be successful. Developing greater ecological validity through a representatively designed task, Klostermann et al. (2017), added a defender to a traditional basketball jump shot task, causing a shortened Quiet Eye (QE) period, compared to the traditional unopposed jump shot. A highly contextualised coupling of perception and action is a vital tenant of perceptual cognitive research, achieved through the design of representative experimental tasks in order to maintain ecological validity and high task fidelity.

This research study set out to investigate the impact of more representative task constraints on a soccer goalkeeping experimental task, utilising the QE as a representative perceptual mechanism.

Method

Four elite professional soccer goalkeepers (26.3 ± 4.2yrs) and six right footed male kickers (21.5 ± 5.9yrs) were selected for the experiment. Head-

mounted SensoMotoric Instruments Eye-tracking Glasses (SMI-ETG) were used to continually assess the goalkeeper's visual gaze, and data were exported via BeGaze software at 60_{HZ}. Calibration followed the manufacturer's specification and was repeated every 5 actions.

A standard penalty kick methodology (PK) (see Dicks et al., 2010) was used as a perceptual research control. A representative task (RK) was designed, (Figure 1), where both attacking player and goalkeeper were in motion throughout the movement.

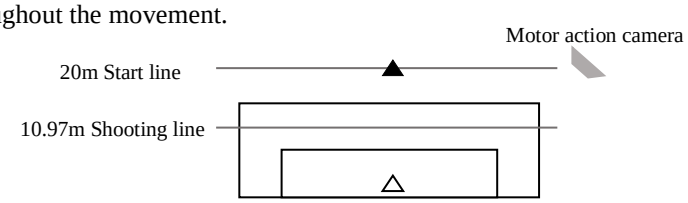

Figure 1: Representative Kick Task. ▲ = Shooting player. △ = Goalkeeper. The shooting player starts from the 20m line and moves freely with the ball to the shooting line, where a shot must occur.

A total of 225 trials were recorded (118 PK; 107 RK) and 101 trials where a successful interceptive action occurred were analysed (42 PK; 59 RK). Gaze and motor data were recorded and then coded following procedures adapted from via a manual Vision-In-Action Klostermann et al. (2017). Paired samples t-tests were used to compare between conditions for the total length of the QE fixation (QE Duration), when the fixation started relative to the trial duration (QE Onset) and when the fixation moves off of the specified location (QE Offset), as well as the fixation location. Statistical significance was set at $p \leq 0.05$ *a priori*. All QE data are presented as relative (%) of the trial duration as mean (±SD).

Results and Discussion

Our results follow previous findings illustrating the tight coupling between perception and action, QE duration, onset and offset all being significantly impacted with the addition of a representative task constraint (Table 1).

Table 1: QE measures data and statistical significance

	QE Duration (%)	QE Onset (%)	QE Offset (%)
Penalty Kick	50.75 ± 2.84	21.13±4.21	73.48±1.58
Representative Kick	45.57 ± 0.93	36.38±4.30	82.40±3.79
Significance	t_2=2.66, $p \leq 0.05$	t_2=4.75, $p < 0.05$	t_2=3.36, $p \leq 0.05$

Interestingly, with the addition of representative task constraints (in the RK) the QE duration was shorter. Further, the QE onset and offset were significantly later in the RK compared to the PK condition. In a more representative task, it appears that the increased uncertainty due to the increased attacking opportunities available, requires the goalkeeper to engage with information later in order to prospectively control actions as the task unfolds.

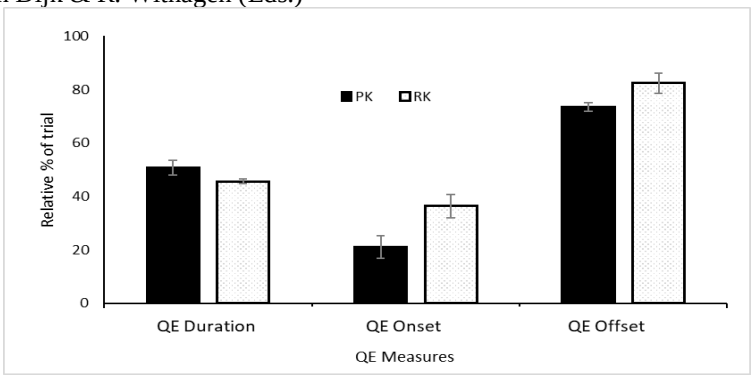

Figure 2: Penalty Kick v Representative Kick showing relative mean (±SD) for QE measures.

The RK task appears to require more functional relationships with visual information. Goalkeepers fixated on the ball more frequently than the visual pivot (VP), located between the ball and kicking leg where it has been said to display temporally constrained information (Kato and Fukuda, 2002), (6.75 ± 2.22 v 2.25 ± 1.26 fixations respectively) in the PK task, and more evenly distributed between the ball and VP (7.75 ± 2.22 v 6.25 ± 3.5 fixations respectively) in the RK. The greater dependence on the VP in the RK may suggest that goalkeepers chose to anchor the fovea near to a specific location so that the parafovea and visual periphery pick up relevant information (Savelsburgh et al., 2002).

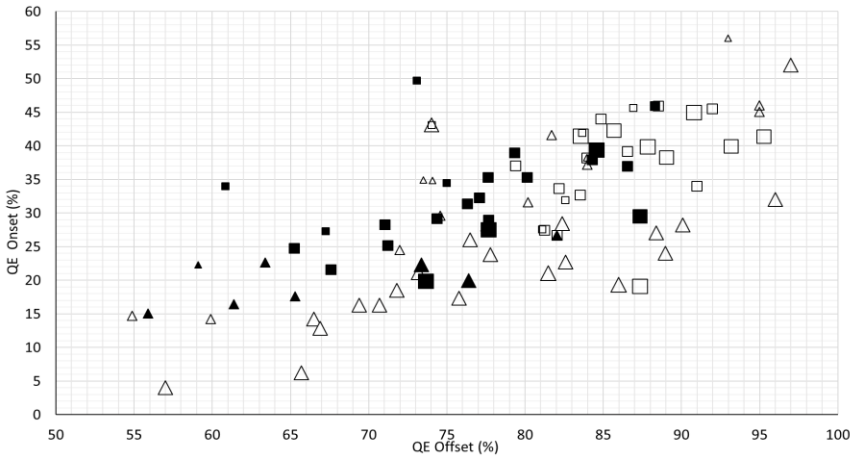

Figure 3: Total raw data for all trials in all conditions presented as relative QE onset and offset for all goalkeepers. Shape: △= PK □= RK; Colour: Black = Fixation at VP, White **= Fixation at ball; Size: ▫ = 15-30% (of total trial length), ▫= 31-50%, □ = 51-75%**

Table 2: Representative Kick v Penalty Kick showing QE measures by fixation location, per condition.

Trial	Location	QE Duration (%)	QE Onset (%)	QE Offset (%)
RK	Ball	45.36 ± 2.78	40.23 ± 3.67	87.13 ± 2.26
	VP	45.43 ± 3.17	32.76 ± 2.21	77.99 ± 5.38
PK	Ball	53.05 ± 3.81	25.71 ± 3.29	78.86 ± 5.74
	VP	45.67 ± 6.02	20.18 ± 1.67	65.79 ± 5.73

The greater use of the VP may provide further evidence that the visual information available to the perceiver, is tightly coupled to the task being completed. The more dynamic performance environment required a broad range of search strategies when fixating on the ball or VP, in response to the increased variability afforded to the shooting player.

The variability present in the visual search strategies across the different locations, within the different tasks demonstrates the temporally and spatially constraining factors present in the task dynamics. The goalkeeper's engagement with functionally varying relationships with the information demonstrates the importance of ensuring representative experimental task design in order to understand skilled behaviour.

Whilst the authors are aware of the limitations present in the statistical power of our analysis due to the low sample size, the elite goalkeepers case study and the representative task design provides important foundations. Whilst further work is required to pursue the impact of representative performance constraints in further contexts, we have shown that with the more appropriate sampling of representative information (Brunkswik, 1955), soccer goalkeepers demonstrate different QE behaviours in response to the alternate task demands.

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