**Time Perception during a Cycling Time Trial**

Human beings have some ability to estimate the passage of time, but are nowhere near as accurate as a clock would be. Under many circumstances, when asked to indicate when they think a particular amount of time has elapsed (e.g. 5 minutes) people tend to indicate that they think the interval is over before it really is.

Nevertheless, how accurately people estimate time is affected by what kind of activity they are engaged in during the estimation interval. Time intervals filled with challenging tasks feel subjectively shorter than those where people are doing nothing. Also, an individual's personality and ability profile can influence their time estimation accuracy. People with good spatial visualisation ability may tend to be more accurate. More impulsive personality types may be more inclined to produce estimates that are shorter than they should be.

During cycling time trials, where a cyclist is required to complete a course of a set distance in the shortest time possible, time estimation is very important skill, enabling the rider to adjust effort over the course to maximise performance without becoming exhausted. However, it may become increasingly difficult to monitor time accurately as a rider becomes more fatigued during the trial.

We were interested in finding out three things. Firstly, we wanted to test whether physical exertion had a predictable effect on the length or accuracy of time estimation. Secondly, we wanted to find out whether using a particular time estimation strategy (e.g. mentally visualising time passing versus mentally counting) would help cyclists to better maintain accurate estimations while they were riding. Thirdly, we wanted to find out whether individual differences in cognitive ability profile or personality affected time estimation or which strategy worked best (e.g. maybe a mental visualisation strategy works best for people with good spatial ability while mental counting is better for people with good rhythm ability).

**Method**

Thirty-eight adult volunteers attended four cycling sessions. In each session, they completed three cycling time trials of 4km in as short a time as possible, riding a stationary bike. During each trial, they were given a start point and asked to indicate when they thought 5 minutes had elapsed. We measured their power output and asked them to rate their level of exertion. The first session was a familiarisation session. In the second session, participants were simply asked to estimate time but given no instruction on how to do this. In the remaining two sessions, participants were either instructed to use a counting strategy (given pre-training and practice using a stopwatch to count seconds) or else a spatial visualisation strategy (given pre-training and practice using an analogue clock to visualise a moving second hand). Participants also completed several measures of dimensions of personality (impulsivity, venturesomeness and empathy) and different specific cognitive abilities (arithmetic, spatial ability, rhythm perception).

We used a "hierarchical" modelling approach to investigate changes in time estimation performance within the same person when using different strategies and applying different levels of effort, and systematic differences between people in their performance and factors that affected them. It also allowed us to test for the effects of specific variables (e.g. impulsivity) while controlling for other variables (e.g. gender).

**Results**

When people were working harder, producing more power and reporting higher levels of exertion, their time estimates tended to become shorter and their accuracy increased over sessions when they put in less effort. Subjective exertion was more strongly associated with *length* of time estimate, while objective power output was more strongly associated with *accuracy* of time estimate.

At low levels of subjective effort, individuals with lower rhythmic ability tended to produce longer time estimates than those with higher rhythmic ability. Higher overall accuracy in time estimation was associated with good spatial ability, low impulsivity and high venturesomeness. Overall accuracy was no different for males and females, and not associated with arithmetic or rhythmic ability.

Different people showed different effects of exertion on *length* of time estimation. For example, males' estimates became much shorter and as their perceived exertion increased, whereas females' estimates were similar in length regardless of perceived exertion. People who were younger, low in empathy, and relatively weak at arithmetic produced markedly shorter estimates at high levels of perceived exertion.

Different people also showed different effects of power output on the *accuracy* of their time estimation. The accuracy of females and more venturesome people increased with greater power output, while males' and less venturesome people's accuracy remained similar regardless of power output.

At low power output, using the visualisation strategy resulted in greater accuracy of time estimates. However, as power output increased, the counting and visualisation strategies were associated with greater inaccuracy. Strategy instruction also tended to negate the advantages of people with good spatial ability and low impulsivity.

**Conclusion**

Cyclists' time estimation accuracy is likely to be enhanced during time trials.

Individual differences in people's specific cognitive abilities, as well as their personality, age and gender, influence time estimation performance and how it changes with objective and subjective exertion in complex ways. Different people may find that different sets of conditions optimise their time estimation performance.

Although the visualisation strategy may be of some benefit to estimation accuracy at low levels of effort, imposed strategies appear to do more harm than good at high levels of physical effort, possibly because of the additional effort required to comply with multiple instructions.