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HOW SPORT ACTIVITIES AFFECT GENERAL DECISION-MAKING ABILITIES IN BOTH DEVELOPMENTAL AGE AND ADULTHOOD

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Abstract

The ability to analyse the available information and make the best decision is essential for human survival. Furthermore, these decisions are made under constraint; we can think about medical doctors, military, or sport athletes. This Ph.D project analysed general decision-making skills in uncertain environments with different levels of uncertainties; to understand whether specific sport practices could increase this ability. A statistical game in which participants had to collect as many points as possible to maximise the score was involved. Young and adult open- and closed-skill sport athletes were recruited: in addition, the present study, only in adult athletes, tested the ability to perform under pressure. We hypothesised that both adult and young open-skill athletes should have better decision ability than closed-skill athletes and the control group. Moreover, closed-skills athletes should be better than the control group. Additionally, according to *Proficiency Efficiency Theory* and *Attentional Control Theory*, we hypothesised a shift of the visual attention to non-relevant or threatening stimuli and an increased performance if participants increase their cognitive effort. The thesis encompasses three experiments: the first one analysed the effect of individual characteristics (e.g., fluid intelligence; personality traits) to determine the potential confounding factors to control in the other two experiments. The second and third experiments analysed the decision-making abilities of young and adult open and closed-skill athletes, respectively. Results highlighted an effect of intelligence in the decision processes. Furthermore, results indicated that young open-skill athletes were better at understanding the environment than young closed-skill athletes. Differently, adult athletes' results revealed that sport activities did not influence decision-making abilities. In addition, the project highlighted that when participants faced the low uncertainty environment, they seemed unable to maximise the score. According to *Prospect Theory*, this behaviour could be given because participants were more oriented to collect points than maximise the gain.

Keywords: general decision-making, transfer learning, sport science, uncertainty, pressure, attentional control theory, proficiency efficiency theory, open-skills sport, closed-skills sport, childhood, statistical decision theory, reinforcement learning, anxiety, personality characteristics

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Author's declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programs and that it has not been submitted for any other academic award. Except where indicated by specific references in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of others, is indicated as such. Any views expressed in the dissertation are those of the author.

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

Interpreting and analysing the available information in order to make the best decision is an important ability for human survival. In many fields, such as military, medical, and sport (Causer et al., 2014, 2013; Rainieri et al., 2020b,a; Ward et al., 2008), the best choice is made based on incomplete information. Moreover, often they are encoded quickly and under pressure (Abernethy, 1996).

This is also happens in everyday life, and an example is a driver who has to make an immediate decision to make the difference between avoiding or having an accident. These abilities could be increased in people who practice physical activity. Indeed, some evidence has supported that regular physical activity leads to many benefits in both physiological and psychological domains.

A series of reviews that examined children, adolescents, and adults show that physical activity leads to an improvement in both physical and psychological well-being (Biddle et al., 2019; Biddle and Asare, 2011; Janssen and Leblanc, 2010; Mann et al., 2007; Russo and Ottoboni, 2019; Voss et al., 2010; Taylor et al., 2004). On the physiological side, the improvement is linked to the loss of fat mass, which is related to the lower risk of developing metabolic diseases and cardiovascular diseases. On the psychological side, well-being is linked to increased self-esteem, better self-concept, better anxiety management, and better attentional process. For instance, a longitudinal study (Zhu et al., 2014) on adults showed an improvement of the physiological parameters (e.g., cardio-respiratory fitness), which generate an improvement of the cognitive aspects such memory and psycho-motor speed. Thus, physical and sport fields might be essential to investigate how these activities increase low and high-order perceptual-cognitive skills.

In the sport field, the large amount of research carried out in recent years highlights the interest in combining the very high physical abilities and the extraordinary perceptive-cognitive skills that distinguish both adult and young athletes, especially those who belong to the élite (Roca et al., 2012; Williams and Ericsson, 2005), from sedentary healthy people. Notoriously, in the sport field there are two research lines. The first one focuses on specific perceptual-cognitive of èlite athletes compared to intermediate and novice ones and/or non-athletes. Specifically, researchers tested the ability to recognise the subtle kinematic movements of opponents and teammates rapidly (if it is a team sport) and the simultaneous assessment of the surrounding environment (e.g., pitch and ball) to make the best decision for that particular situation (Abernethy et al., 2008; Aglioti et al., 2008; Alder et al., 2014; Mann et al., 2007). This research highlighted better performance for élite and expert athletes compared to less expert ones and novices. Instead, the second research line focuses on athletes' general basic cognitive skills of athletes compared to intermediate/novice athletes and lay-people. This allow to understand whether the sport practice might lead to brain changes or changes in behaviour that allow èlite athletes better to analyse general information than others in everyday tasks. These investigations were summarised in some systematic reviews and meta-analysis (Russo and Ottoboni, 2019; Scharfen and Memmert, 2019; Voss et al., 2010). In summary, this could represent the ability to transfer expertise acquired in their own domain across different domains that could increase people's well-being.

Even if there are some exceptions, results highlighted better cognitive function for expert athletes than less-experts and laypeople. However, most of these investigations have focused on basic cognitive function while high order cognitive ability such as problem-solving, reasoning, and general decision-making are less investigated in both young and adult athletes.

Actually, according to piece of evidence, abilities acquired in a specific sport domain such as decision-making and anticipation can be transferred across domains. Specifically, these investigations have shown that it is possible to transfer high-order specific perceptual-cognitive skills in similar sport such as tennis and badminton (racket sports; Abernethy et al. 2008), football and basketball (team sports, Roca and Williams 2017), but not in dissimilar sports such as tennis and football, (Roca and Williams, 2017). This was also proved by a recent research Roca and Williams (2017) that highlighted footballers can transfer their anticipation skills to basketball, but not to tennis sport.

Furthermore, other investigations would support the hypothesis that acquired skills can also be transferred to completely different areas such as the economic or managing one. An example is the study on "top level" and "low-level" basketball and handball coaches, problem-solving and non-specific decision-making skills are better in the former than in the latter participants (Hagemann et al., 2008). Another study on young football players with the IOWA gambling task revealed different behaviour between forward and defensive players. The former were more prone to have risky behaviour while the latter were more reflective about decisions and preferred less risky choices (Gonzaga et al., 2014). However, despite of these results, less is known about transferring of high-order perceptual-cognitive skills such as decision-making in non-specific domains and it is matter of debate.

Furthermore, it should also be noted that although these skills are excellent in professional sportsmen and sportswomen, the stress factors could affect their effectiveness in performance. Indeed, psycho-physiological states play a fundamental role in modulating the ability to take advantage of the information one comes into possession. The hypothesis that states of strong anxiety reduces peripheral vision and makes the individual unable to divert attention from some stimuli at others' expense is increasingly supported. However, according to the Proficiency Efficiency Theory (PET, Eysenck and Calvo 1992) and the Attentional Control Theory (ACT, Eysenck et al. 2007), performance could be increased when under psychological pressure, but at the expense of the general efficiency (Mohanty and Sussman, 2013; Oudejans and Pijpers, 2010; Vater et al., 2016; Vickers and Williams, 2007; Williams, 2009; Williams and Elliott, 1999). Thus, athletes may be able to govern these emotional states better than laypeople when making everyday decisions.

1.2 Thesis purposes

The present Ph.D project aimed to investigate adult and young athletes' decision-making abilities to understand whether the skills acquired in their individual sport domain can be transferred to non-sportive domains.

This was also tested in developmental age to help physical education teachers and coaches in developing appropriate physical education and training programs for their pupils.

Moreover, at the same time, the research project also evaluated the ability to manage the stressful states in adult athletes.

Thus, this PhD project would like to understand whether sport practice is fundamental for the growth of individuals' psycho-physical well-being.

Decision-making is defined as a process to analyse information and select the more relevant and choose the best option among a series of possible choices (Bang and Fleming, 2018; Raab, 2007) To analyse the decision-making skills, a novel statistical decision task was employed (see Sub-Chapter 1.3.1). This task allowed to test how participants adapted their behaviour in an uncertain environments and when exposed to stressful conditions (Chapter 4).

In the first experiment (Chapter 2), statistical decision processes were evaluated testing laypeople controlling for several confounding factors: specifically, fluid intelligence (Raven and Court, 1998) and some personality characteristics, i.e. Extra-Introversion, Psychoticism, Neuroticism, (Eysenck and Eysenck, 1994), and Trait Anxiety (Spielberger 1983, Sub-chapter 1.3.3). This experiment was conducted to analyse whether these confounding factors were important in resolving the above-mentioned decision task (see Chapter 2).

In the second experiment (Chapter 3), decision-making abilities were analysed in pre-adolescent children who were practicing open- or closed-skill sports.

Open-skill sports are sport characterised by high level of uncertainty and athletes should adapt their behaviour to the environments' mutable situation (Russo and Ottoboni, 2019; Voss et al., 2010). Examples of open-skill sports are football, basketball, and tennis. Instead, Closed Skill sports are performed in relative stable environments, and examples are running, cycling, and swimming (Russo and Ottoboni, 2019; Voss et al., 2010). In the third experiment (Chapter 4), the effect of a stressful condition on participants' performance was investigated using the same statistical decision-making test in élite open- and closed-skill sport athletes and laypeople. Pressure effect were analysed through psycho-social (e.g., questionnaires) and physiological measures (e.g., eye-movments and hear rates). Because in Study 1 (Chapter 2), we found fluid intelligence affected the resolution of the task; thus it was monitored in Study 2 and Study 3 (Chapter 3 and Chapter 4, respectively).

1.3 Research instruments

Several research instruments were adopted in order to complete the project. Specifically, the project involved a decision-making task (Sub-chapter 1.3.1), a personality traits questionnaire (Sub-chapter 1.3.3), and physiological measures (Sub-chapter 1.3.4). Each of them was explained in the following sections.

1.3.1 Statistical decision-making task

Researchers in economics, psychology, neuroscience, sport science, and mathematics are attracted to understand the mechanisms underlying these processes because in every circumstance of our lives, we have to make decisions.

Decision-making is when people have to identify and choose among possible alternatives based on values, preferences, and beliefs the most suitable option (Edwards, 1954). During the years, several types of tasks have been developed, and researchers continue developing them to better analyse the above-mentioned processes. One of the methods to study the decision-making processes is to investigate them under uncertainty. Namely, researchers create tasks in which participants had to make choices based on partial information about the environment. Moreover, the available information about the environment change. If compared to the categorical setting, the task developed in this project can be associated with statistical decision theory (Berger, 1989; Slovic et al., 1977), in which participants are exposed to a series of repetitions on the base of which participants may learn from the past and they can develop an internal model of the environment in order put in action strategies to manage and exploit the environment.

According to the statistical decision theory (Berger, 1989), these tasks allow researchers to understand participants' decision-making process and how people can find a strategy to perform optimally. Moreover, these tasks grant researchers to understand the behaviour also in a mathematical way.

In the present research project, the task (Sub-chapter 1.3.1) consisted of a modified version of the task used by Larsen and Coricelli (2017), O'Reilly et al. (2013) and Vaghi et al. (2017).

The task is a statistical game where participants were prompted to gain the highest score possible. Participants should create an internal model of the environment to find the trade-off between winnings and losses to maximise the score.

The score is assigned every time participants intercept a dot falling from the centre of a circumference towards its board (see Fig. 1.2).

Goal was achieved by locating a bucket along the circumference with the aim to predict the location of the events. Participants saw a series of similar events with a predetermined variability (σ^*, Sub-chapter 1.3.1, Fig. 1.1).

The task presents another feature: differently to the task of Vaghi et al. (2017) and similar to Larsen and Coricelli (2017), to achieve a higher score participants can tune the bucket's length: the smaller the bucket, the higher the score. With this mechanism, it is possible assess the implicit confidence and/or participants' risk willingness (Kepecs and Mainen, 2012). Indeed, we assume that when participants became more confident with the environment, they should be willing to decrease the length of the bucket and try to earn more points until a certain level defined by an Optimal Decision Maker (OUM, Sub-chapter 1.3.1.3). Moreover, differently to Larsen and Coricelli (2017) task, we increased the uncertainty of the task (for the characteristics of the task see Sub-chapter 1.3.1). Participants can move and shrink the bucket until the dot release, which is decided by each participant by pressing the space-bar. The score increased linearly: two points every two degrees of length. In the optimal case, i.e., when a dot was intercepted, participants could gain 88 points resulting in a 2-degree bucket. On the other hand, no points were provided when the bucket length subtends 45° (see Fig. 1.2).

The bucket's modulation was totally free, and the bucket did not change its length automatically at the end of the trial or the block.

Additionally, some information such as the points gained until that moment, the amount of points bet and the time remaining before passing to the next trial were presented (Fig. 1.2). To compare participants' behaviour and performance, we created an Optimal User Model (OUM, Sub-chapter

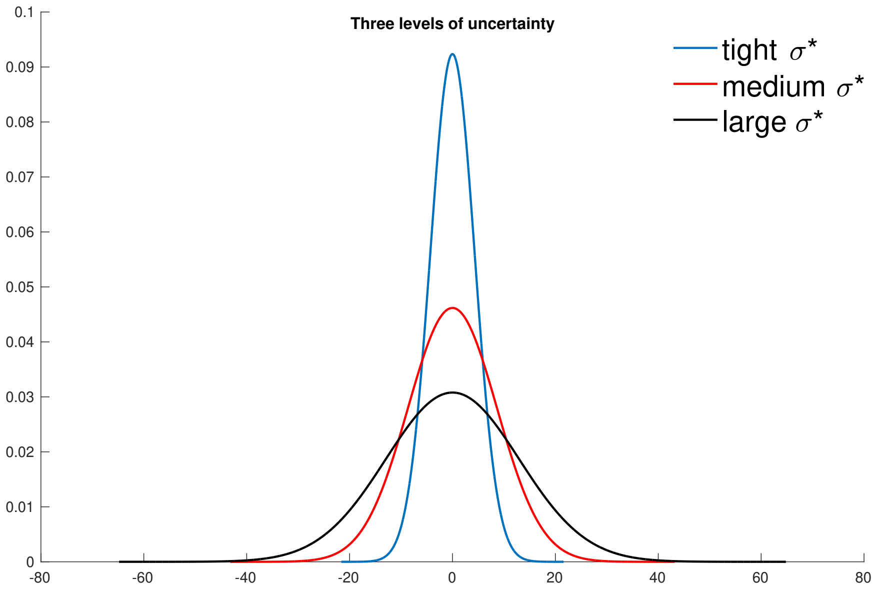


Figure 1.1: The chart shows the three levels of uncertainty (conditions). The blue distribution represents the tight σ^*, the orange one represents the medium σ^* and the black line represents the large σ^*.

1.3.1.3).

1.3.1.1 Task creation

The task was programmed in MatLab (MathWorks - MATLAB 2018) via Psychophysics Toolbox Extension 3 (Kleiner et al., 2007).

The task was programmed following these rules: first of all, we defined the random variable $dir_{t,i}^{pre}$, $i = 1,\ldots,8$, which outputs each of the eight expected directions.

We set $dir_{t,i}^{pre} \sim N(45° \times i, 10°)$, $i = 1,\ldots,8$. From this sampling process, we obtained eight directions $dir_{t,i}^{*}$, $i = 1,\ldots,8$. We then re-sampled four more

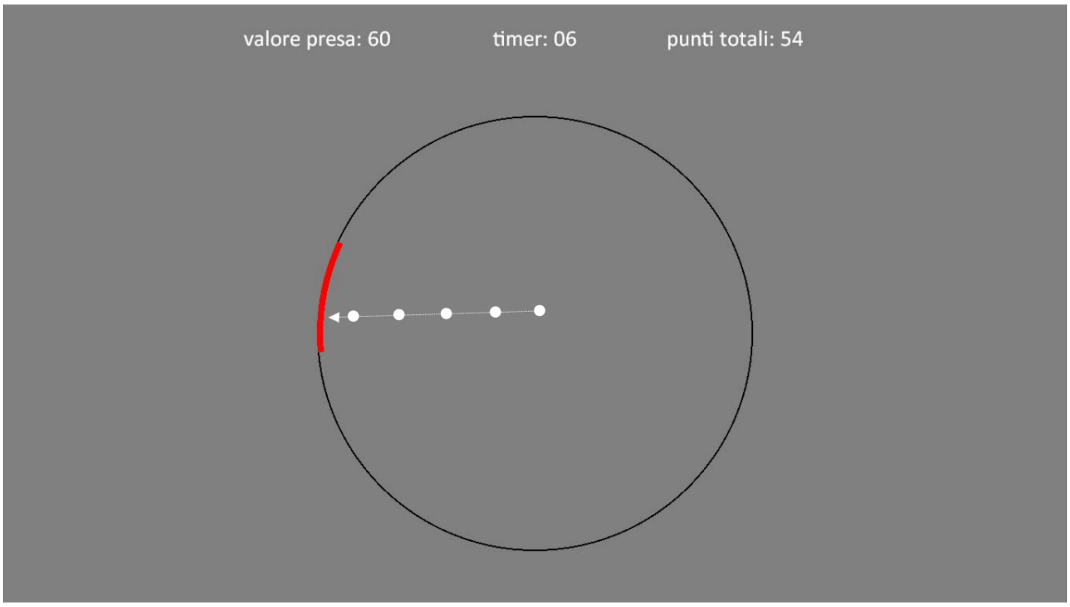


Figure 1.2: The image shows a trial of the task. Participants could move the red bucket along the circumference and they could set the length. When they press the space-bar a dot from the centre to the peripheral moved.

directions from the eight already extracted thus obtaining 12 directions $dir^*_{t,i}$, $i = 1,\ldots,12$.

Suppose that we fix i^*, a number in the set $1,\ldots,12$. We call dir_t the random direction referred to the generic i^*. We set $dir_t \sim N(dir^*_t, \sigma^*)$, $t = 1,\ldots,t_i$, $t_i = 12,14,16,18$, $\sigma^* = 4.32°(tight), 8.64°(medium), 12.96°$ (large, See Figure 1.1).

For us, $\hat{dir}^U_t$ is the direction chosen by the user and $\hat{dir}^C_t$ is the extracted direction. In order to avoid consecutively use of two similar extracted directions (i), a minimum of 40° from one i to the next one was requested.

Participants performed a total of 12 blocks with 180 trials (60 trials for each condition). Blocks and their length were randomly assigned to each participant.

1.3.1.2 Parameters

Behavioural parameters

With the purpose to measure participants' behaviour and performance in this decision task (Sub-chapter 1.3.1), some parameters were created. Some of them were developed comparing participants' performance and the one provided by an optimal data-driven decision-maker (Optimal User Model, OUM, Sub-chapter 1.3.1.3).

In particular, we computed: the *Spatial Error* (*SE*, Equation 1.1) in order to analyse how participants understand the possible future dots direction; the *Gain* in order to analyse the ability to maximise the score (points) collected in each trial; the *Gain Error* (Equation 1.2) to understand whether participants were able to reach the OUM score (Sub-chapter 1.3.1.3); the *Standard Deviation Error* (*SD-E*, Equation 1.3) that represents the ability to set the best bucket length as a function of the level of uncertainty participant was exposed every time compared to the hypothetical one to maximise the score; the σ^U represents the modulation of the bucket across the time in the three levels of uncertainty (σ^*) and it was associate to the bet in the decisions.

$$\text{(1.1)} \qquad Spatial\ Error = \sum_{t=1}^{n} |dir_t^c| - dir_t^U$$

Spatial Error (*SE*, Equation 1.1) was computed by subtracting the value calculated by averaging all the positions of the dots landings until the previous trial ($\sum_{t=1}^{n} |dir_t^c|$), from the value representing the position of the center of the bucket inside the circumference at the landing of the dot (dir_t^U). The closer the value was to 0, the higher the performance. As reported in Sub-chapter 1.3.1.3, OUM model was perfectly able to compute the average of dots direction, thus, *SE* could be seen as a comparison between human and OUM mode l (Sub-chapter 1.3.1.3). The *Gain* was the amount of points collected in each trial. Higher the *Gain*, higher the ability to maximise the score. The *Gain Error* was the difference between points collected by OUM (Sub-chapter 1.3.1.3) and points collected by participants (Equation 1.2). It could be a negative or positive value. The closer the value was to 0, it meant the participants were closer to OUM (Sub-chapter 1.3.1.3). Positive values meant participants collected less points than OUM, contrary for negative values.

$$\text{Gain Error} = Score_t^{OUM} - Score_t^{U} \tag{1.2}$$

$$\text{SD-Error} = \sigma_t^U - \sigma_t^{OUM} \tag{1.3}$$

Standard Deviation Error (SD-E) was calculated making the differences between the bucket length adopted by participants (σ_t^U) and the bucket length of the Optimal User Model (σ_{OUM}, Sub-chapter 1.3.1.3) for each trial. Similar to *Gain Error*, the closer the value was to 0, it meant the participants were close to OUM (Sub-chapter 1.3.1.3). Positive values meant participants set the bucket length larger than OUM (Sub-chapter

1.3.1.3), while negative values represented that participants set the bucket length shorter than OUM (Sub-chapter 1.3.1.3).

User's bucket length (σ^U) was the bucket length of participants across trials. Bucket length represented the bet on decisions.

1.3.1.3 Optimal Computational Model

The Optimal Computational Model (OCM) was created to check whether the participants were able to find the best solutions for each σ^*. This computational model was created with the help of Dr. Matteo Farné of the Department of Statistic – University of Bologna.

We started from creating Optimal Computation Model (OCM) that was implemented according to the prior knowledge of the task following these rules. Suppose that, among the possible scores for a single trial, $s = 0, 2, 4, \ldots, 88$, we determined the score s^* such that $s^* = \max_s sP(S_t \geq s)$, where S_t is the random score of a single trial t. The optimum s^* is the maximum achievable outcome discounting the score for the probability to reach a value not smaller than s^*. The random score S_t was equal to $88 - i$ when the catcher lies into the interval $[dir_t^C - i°, dir_t^C + i°]$, $i = 88, 86, 84, \ldots, 0$. To determine the behaviour of an optimal user, we set $dir_t^C = dir_t^* = 0$ (with no loss of generality) and we studied the link between the random score S_t and the random position P_t of the catcher.

We know that P_t behaved like a $N(0, \sigma^*)$, where $\sigma^* = 4.32, 8.64, 12.96$. Therefore, we could calculate $P(S_t \geq s)$ as $P(P_t \in [-(90 - s°), (90 - s°)]) =$

$2(F_P(90-s)-F_P(0)) = 2(F_P(90-s)-0.5)$, where F_P was the evaluated distribution function of the random position P_t. Therefore, determining empirically $s^* = \max_s sP(S_t \geq s) = \max_s s(F_P(90-s)-0.5)$, we knew as a consequence that the optimal user-related sigma, $C_U^* = 90-s^*$ For $\sigma^* = 4.32, 8.64, 12.96$, empirical results show that $s^* = 10(20), 18(36), 22(44)$ if $s = 0, 2, 4, \ldots, 88$.

Moving by the definition of the OCM, we introduce the Optima User Model (OUM), to make the OCM useful for real decision making. In order to do that, we adapt the OCM as follows. First, we now assume that the expected direction and the standard deviation of the catcher are unknown. At the first step, we draw dir_1^{OUM} from $Unif(0,360)$ and σ_1^{OUM} from $Unif(0,90)$. For $t = 2$, we set $dir_2^{OUM} = dir_2^C$, while we again draw the catcher's standard deviation σ_2^{OUM} as $Unif(0,90)$. From trial $t = 3$ to $t = T$ we are able to estimate $dir_t^{OUM} = (\sum_{i=1}^{t-1} dir_{t-1}^C)/(t-1)$ and $\sigma_t^{OUM} = \sqrt{\sum_{i=1}^{t-1}(dir_{t-1}^C - dir_t^{OUM})^2/(t-2)}$. For each trial from 3 to T, we then calculate the FOCM catcher's width $\hat{s}^{OUM}$ as $\hat{s}_t^{OUM} = \max_s s\hat{F}_P(S_t \geq s)$, where $\hat{F}_P$ for each trial t is the normal distribution function with mean dir_t^{OUM} and σ_t^{OUM}.

Random experiments show that from trial 6/7 dir_t^{OUM}, σ_t^{OUM} and $\hat{s}_t^{OUM}$ converge to dir^*, σ^*, and s^* respectively.

1.3.2 Fluid intelligence task

1.3.2.1 Raven - Advance Progressive Matrices (APM)

The Raven-APM task (Raven and Court, 1998) was employed to investigate the fluid intelligence of participants. Raven-APM Series II required participants to solve 36 matrices within the time limit of 40 minutes in Study 1 (Chapter 2) and 20 minutes in Study 2 (Chapter 3). Twenty minutes Raven-APM task (Raven and Court, 1998) was preferred to 40 minutes one, because it is well correlated to the 40 minutes version (Hamel and Schmittmann, 2006) and because Sport Associations involved in the project gave us limited time to test their athletes.

Each matrix provided 8 possible choices, but only one correct (see Fig. 1.3). Forty minutes Raven-APM task was programmed in E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). 20 minutes version instead was programmed through Psychtoolbox (Kleiner et al., 2007) in MATLAB (MATLAB, 2018).

In both versions, participants practised with the task solving the first 6 trials of Raven-APM Series I: in case they exerted some difficulties, they were prompted to ask for more information to the researcher. The task was accomplished with a distance of ~ 600 mm from the screen. The task ended when participants finished the task or when time was running out.

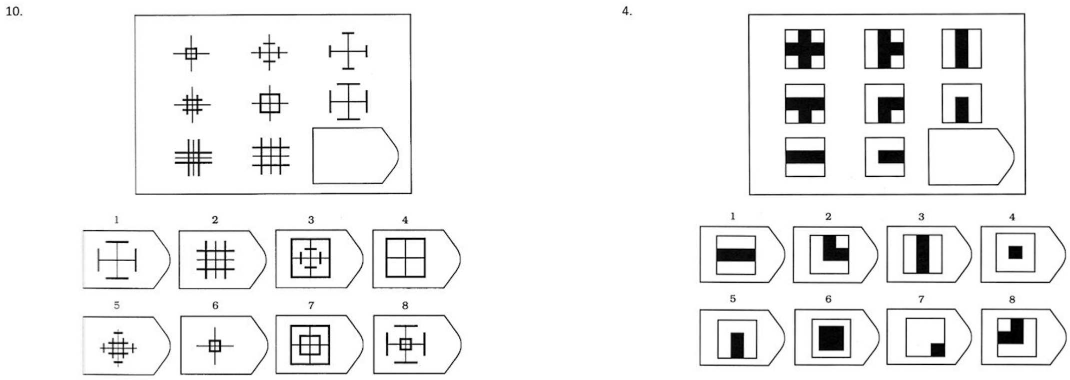


Figure 1.3: Two trials of Raven-APM task.

1.3.2.2 Raven - Coloured Progressive Matrices (CPM)

The Raven-CPM (Raven, 1958) task was employed in Study 2 (Chapter 3) in order to examine the fluid intelligence of pre-adolescents.

Raven-CPM was programmed in E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). It consists of 36 matrices with six possible choices, but only one correct (see Fig. 1.4).

Pre-adolescent had 40 minutes to complete all of them. When the time was up, the software ended the task.

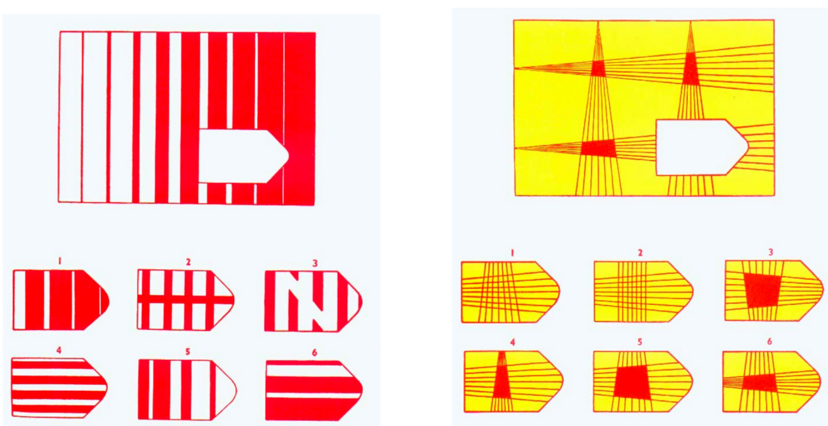


Figure 1.4: Two trials of Raven-CPM task.

1.3.3 Questionnaires and Scale

Questionnaires employed in this research project were: Eysenck Personality Questionnaire (EPQ-r, Eysenck and Eysenck 1994), State and Trait Anxiety Questionnaire (STAI, Spielberger 1983), Rating Scale Meantal Effort (RSME, Zijlstra 1993). Eyeseck Personality Questionnare evaluated some people psychosocial features such as Extra/Introversion, Neuroticism and Psychoticism. STAI questionnaire, instead, evaluated state and trait anxiety. EPQ-r (Eysenck and Eysenck, 1994) and STAIT (Trait Anxiety) were employed in Study 1 (Chapter 2) in order to analyse participants features. Specifically, in Study 1 (Chapter 2), the questionnaire examined trait anxiety while in Study 3 (Chapter 4) examined state anxiety to control pressure induction.

Moreover, in Studies 1 and 3 (Chapter 2 and Chapter 4) we analysed the mental effort through the Rating Scale Mental Effort (RSME, Zijlstra 1993; Fig. 1.5).

In Study 1 (Chapter 2) it was involved to analysed whether the participants put in action all their cognitive resources. Study 3 (Chapter 4) instead analysed whether under pressure, participants increased their cognitive effort as hypothesised by *PET* and *ACT* (Eysenck and Calvo, 1992; Eysenck et al., 2007).

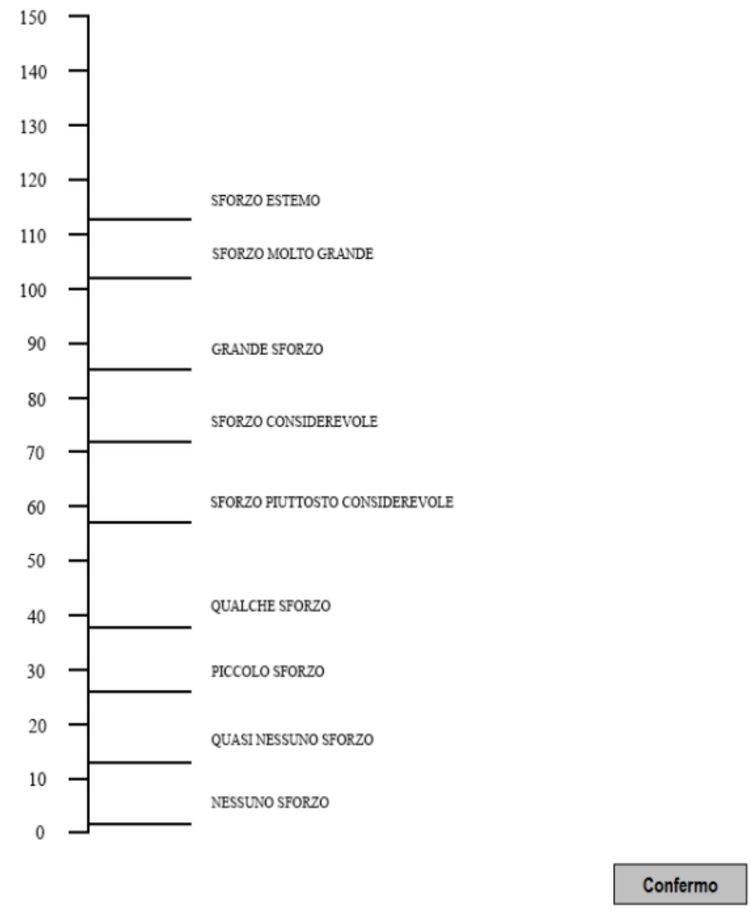


Figure 1.5: Rating Scale Mental Effort (Zijlstra, 1993). Respondents clicking with a mouse chose their mental effort on a scale 0 - 150 where 0 was no-effort and 150 extremely high effort.

1.3.4 Physiological measures

Through a Tobii eye-tracker and a heart rate (HR) monitor, participants' physiological parameters were recorded. Specifically, they were employed in the study 3 (Chapter 4) to verify *ATC* and *PET* theories (Eysenck and Calvo, 1992; Eysenck et al., 2007) on the statistical decision task. In particular, the eye-tracker analysed the visual behaviour while the HR monitor measured the heart rate during the task due to its strong relation with somatic pressure.

CHAPTER 2

Study 1 — How intelligence and psycho-social features affect the decision-making process in a statistical decision task

2.1 Introduction

In every situation, people need to make decisions under different levels of uncertainty. In order to master it, people analyse the fragmented information calculating the probability that a certain event may happen while seeking the best trade-off between costs and advantages (Bang and Fleming, 2018; Kepecs and Mainen, 2012; Slovic et al., 1977; Yeung and Summerfield, 2012). For instance, if we consider financial investments, people could choose to invest their money in the stock market featured with high risk, but with a potentially high return, or to invest resources in bonds where the risk is low and returns are certain.

In this process, several factors are involved: knowledge about the environment, learning, belief and desires (Berger, 1989, 1990).

According to several investigations, these decision processes are mediated by cognitive functions and personality traits. For instance, fluid intelligence supports the best choice selection process. Its impact is exerted by influencing the integration and processing of the analysed information (Miceli et al., 2018; Stupple et al., 2011; Trippas et al., 2018).

However, its role seems to vary according to several factors. Some authors highlighted that in tasks that featured high levels of difficulty and complexity (e.g. dynamic decision task), fluid intelligence exerted its influence compared to less complex decision tasks (e.g., IOWA gambling task; Del Missier et al. 2012; Gonzalez et al. 2005).

For what concerns psychological traits, instead, neurotic and high trait anxiety people are both less prone to make risky decisions and have poorer performance when they face high-pressure situations (Byrne et al., 2015; Lauriola and Levin, 2001; Hartley and Phelps, 2012). Introversion, instead, seemed to help in the decision-making process. According to a recent investigation, introverted people are prone to make more utilitarian decisions than extroverted individuals when facing moral dilemmas (Tao et al., 2020). Furthermore, they performed better than extrovert ones, because they make decisions based on their intuition, while extroverts put in action snap decisions without thinking about the future consequences (Khalil, 2016).

To the best of our knowledge, the impact of both intelligence and personality traits on the way people adapt to a probabilistic decision task such as this one has not been studied yet.

In order to analyse participants' behaviour and performance, *Spatial Error* (*SE*, Eq. 1.1), *Gain*, *Gain Error* (Eq. 1.2), *Standard Deviation Error (SD-E)* (Eq. 1.3) and σ^U were computed (see Sub-chapter 1.3.1.2 for a detailed explanation of these parameters).

Overall, we expected that the parameters improve overtime to reach the OUM's optimal values (Sub-chapter 1.3.1.3).

In particular, we assumed that participants tried to find the best position to locate the bucket computing an average of the direction of the dots. Moreover, participants should reduce the bucket length (σ^U) to find the optimal bucket to maximise the *Gain Error* and *SD-E*.

In addition, by capitalizing on Gonzalez et al. (2005)'s findings, we expected that participants featured with higher intelligence showed better *SE*, *Gain* and *Gain-Error* than their counterparts.

However, as the willingness to risk should not associate with intelligence, we did not expect differences in the modulation of the bucket length (σ^U) and in the *SD-E*.

Regarding the personality traits, we expected better performance for introverted and non-neurotic people in *SE*, *Gain* and *Gain-Error*: introverted and non-neurotic people are used to reason and evaluate environmental pros and cons than their counterparts (Lauriola and Levin, 2001; Tao et al., 2020). Furthermore, we expected that extrovert participants should reduce more the bucket length σ^U compared to introverts because of their willingness to risk more than introverted people. In order to control these data, the mental effort involved in the task was controlled. In this way, it was possible to consider whether some groups were more focused on the task than others.

2.2 Methods

2.3 Participants

Forty-one healthy participants were recruited. No participants had any history of neurological and psychiatric disorders or head injury. Participants were aged between 20 and 34 years old ($M_{age} = 24.61$, $SD_{age} = 2.62$ years old) and 9 of them were females (**Females** $M_{age} = 23.88$, $SD_{age} = 0.99$ years old; **Males** $M_{age} = 24.81$, $SD_{age} = 2.89$ years old). In order to study the personality effect on the decision task, participants were divided below and above the median of the score of the filled questionnaires (Eysenck and Eysenck, 1994; Spielberger, 1983) and of the score obtained in the Raven-APM task (Raven and Court, 1998).

Overall, the mean participants' score was 23.02 ($SD = 5.62$), with a median of 22 matrices. Raven A group completed a mean of 27.4 ($SD = 3.5$) matrices correctly, and the Raven B group completed a mean of 18.9 ($SD = 3.8$) matrices. EPQr questionnaire assessed participants' personality traits. In particular, we focused our attention on Extra/Introversion and Neuroticism. The sample was divided by the median into Extrovert people and Introvert people, Neurotic and non-Neurotic people, and High Trait Anxiety and Low Trait Anxiety people. The median of Extroversion was 10.5 points, the median of Neuroticism was 3.5 points, while Trait Anxiety was 38 points.
The study was approved by the Bioethics Committee of the University of Bologna in 2018 (Fig. A.1). Informed consent was obtained by each participant before the beginning of the experiment (see Fig. A.5).

2.4 Procedure

Before starting the experiment, participants filled the informed consent and the psycho-social questionnaires, e.g., STAI and EPQr questionnaires (Spielberger 1983; Eysenck and Eysenck 1994, respectively). After that, participants performed the perceptual decision task and Raven-APM task. Before each task, participants received the instructions to perform the tasks. Participants carried out the task in a quiet place in order to maximise their concentration. At the end of the decision task, participants reported the mental effort involved in the task (see Sub-chapter Fig. 1.5).

2.5 Data Analysis

Data was analysed with R Software (R Core Team, 2013) through RStudio software (RStudio Team, 2015). Decision-making Data was analysed as panel data thus, we created a linear mixed-effects regression model (Bates et al., 2015) with Trial factor as fixed time effects. The independent variables were: Condition (σ^*, 3 levels, Tight, Medium and Large); Intelligence (2 levels: Raven A and Raven B), Extroversion (2 levels: Extrovert and Introvert), Neuroticism (2 levels: Neurotic and non-Neurotic), Anxiety Trait (2 levels: High Anxiety Trait and Low Anxiety Trait), and as previously said the Trial factor was time effect (11 or 10 levels). Subject was set as the random factor. *Spatial Error*, *SD-E* and σ^U data were ranked transformed in order to reduce the non-normality and the heteroskedasticity.

Data recorded from the task were analysed in the following way: for the *Spatial Error*, *Gain* and σ^U, the first trial after the beginning of a new condition of dot throws was removed from the analysis, as well as trials after the 12^{th} were removed. This allowed having the same numerosity of each trial (i.e., 11 trials for each participant were analysed). In *Gain Error* and *SD-E*, even the second trial was removed from the analysis because both human and OUM (Sub-chapter 1.3.1.3) could not estimate the standard deviation of throws direction.

Analysis on Rating Scale Mental Effort score (Sub-chapter 2.6.1) was conducted with a linear regression model where the dependent variable was RSME score while the independent variables were Intelligence, Extroversion, Neuroticism and Trait Anxiety.

2.6 Results

2.6.1 Mental Effort

Linear regression on RSME score revealed that none of the single factors were significant ($F(37,1) < 2.61$, $p > .05$).

2.6.2 Statistical Decision Task

2.6.2.1 Spatial Error (SE)

The step-wise panel regression approach with SE as dependent variable reveals that personality characteristics, i.e., Extra/Introversion and Neuroticism, are not significant ($F < 1.90$, $p > .05$), as well as their interaction with the Condition factor, which represents the three different scenarios for σ^* ($F < 2.84$, $p > .05$).

The final linear mixed-effects regression model revealed that Condition was significant ($F(2,1278) = 128.59$, $p < .0001$). Post-hoc analysis on Condition highlighted a systematically better performance in Tight σ^* compared to Medium σ^* and Large σ^* ($t(1278) = 5.55$, $p < .0001$; $t(1278) =$

$15.81, p < .0001$, respectively). Moreover, *SE* is significantly higher for the Medium compared to the Large σ^* ($t(1278) = 10.26$, $p < .0001$).

The Intelligence factor was significant ($F(1,39) = 5.45, p = .03$), with Raven A showing a better Spatial Error than Raven B. The interaction between Condition and Intelligence was significant ($F(2,1278) = 4.16$, $p = .02$, see Fig. 2.1). Post-hoc analysis reveals that Raven A participants are better than Raven B in Tight σ^* ($t(54.8) = 3.15$, $p = .02$), while nonsignificant differences between Raven A and Raven B in Medium and Large σ^* emerge (Medium σ^*: $t(54.8) = 2.11$, $p > .5$; Large σ^*: $t(54.8) = 1.17$, $p > .05$). Both groups showed a better *SE* in the Tight compared to the Medium σ^* (Raven A: $t(1278) = 4.93$, $p < .0001$; Raven B: $t(1278) = 2.90$, $p = .04$) and the Large σ^* scenario (Raven A: $t(1278) = 13.07$, $p < .0001$; Raven B: $t(1278) = 9.25$, $p < .0001$). Moreover, *Spatial Error* was statistically lower under Medium σ^* compared to Large (Raven A: $t(1278) = 8.13$, $p < .0001$; Raven B: $t(1278) = 6.36$, $p < .0001$). Trial factor was significant ($F(10,1310) = 132.35$, $p < .0001$) as well as their interaction with Condition factor ($F(20,1310) = 4.21$, $p < .0001$).
Due to some limit of EMMEANS package (Lenth et al., 2018), in order to understand trial effects on *SE* parameter, as Post-hoc analysis, we performed a linear mixed-effects model for each σ^*.

Analysis on Tight σ^* showed Trial factor was significant ($F(10,400) = 9.70$, $p < .0001$). Post-hoc analysis reveals that Trial 2 was significantly

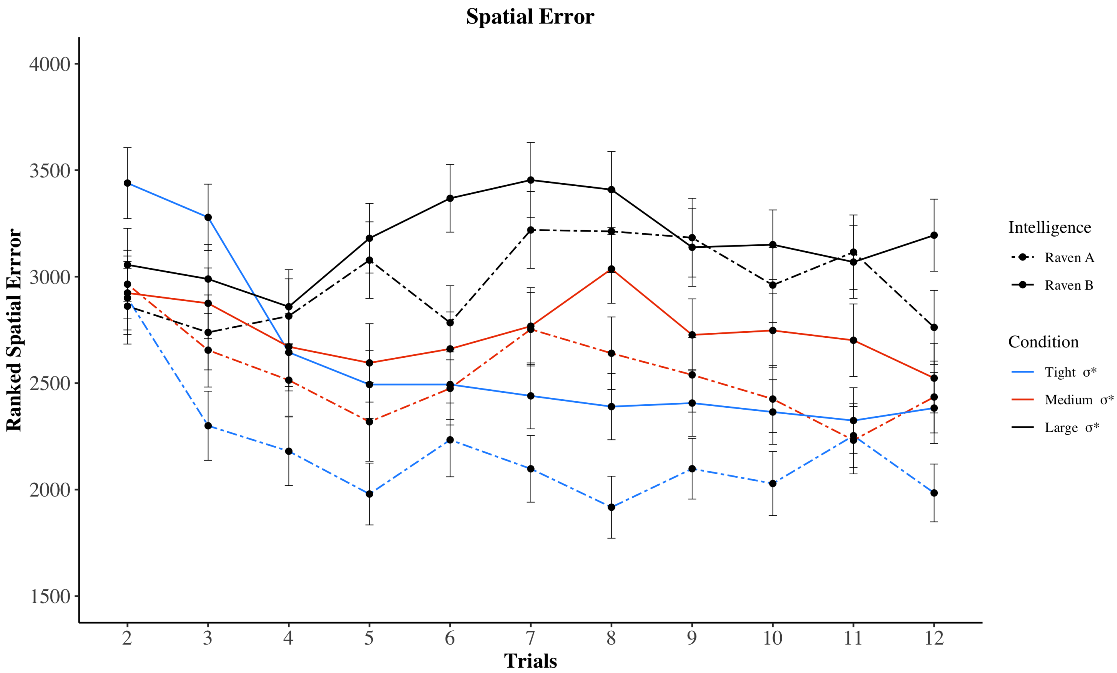


Figure 2.1: Raven A and Raven B *Spatial Error* in the three conditions (σ^*s).*SE* average and SEM for each trial and each σ^* of Raven A and Raven B groups are reported. Fig. 2.2 shows *SE* in the three σ^*s separately.

different from all others Trials ($t(400) > 4.71$, $p < .05$) except from Trial 3 ($(400) = 2.16$, $p = .4$). Trial 3 was also significantly different from Trials 5, 8, 9, 10, 11, and 12 ($t(400) > 4.44$, $p < .05$), while Trial 3 was not different from Trials 4 and 6 ($t(400) < 2.54$, $p > .05$). A trend towards to significance was found between Trial 3 and and 7 (t (410) = 3.15, p = .07). From Trial 4, all other pairwise comparisons were nonsignificant ($t < 2.50$, $p > .05$).

Analysis on Medium σ^* reveals Trial factor was significant ($F(10,400) = 1.84$, $p = .05$). Post-hoc analysis comparisons highlight differences between Trial 2 and Trial 11 ($t(400) = 3.29$, $p = .04$). Furthermore, a trend toward to significance was found between Trial 2 and Trial 12 ($t(400) = 3.20$, $p = .06$). All other pairwise comparisons were nonsignificant ($t < 2.40$,

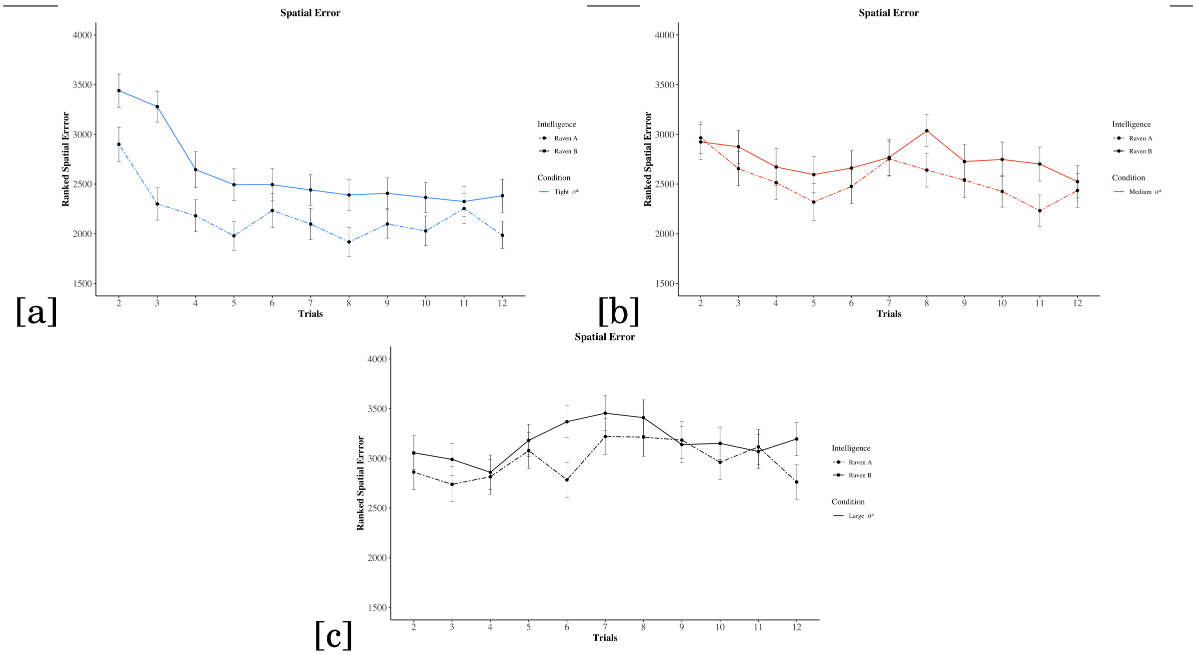


Figure 2.2: Fig. 2.2a shows *SE* (Eq. 1.1) in the Tight σ^* where the uncertainty was low; Fig. 2.2b *SE* shows the Medium σ^* while Fig. 2.2c shows SE in the condition that was characterised by high variability (Large σ^*).

$p > .05$).

Analysis on Large σ^*, revealed significant differences for *SE* ($F(10,400) = 3.35$, $p = .0003$). Post-hoc analysis revealed that Trial 3 was systematically different from Trial 7 and Trial 8 ($t(400) = 3.57$, $p = .02$, $t(400) = 3.40$, $p = .03$, respectively). Moreover, the analysis showed statistical differences between Trial 4 and Trial 7 ($t(400) = 3.73$, $p = .006$) and Trial 4 and Trial 8 ($t(400) = 3.71$, $p = .01$). All remaining pairwise comparisons were nonsignificant ($t < 3.03$, $p > .05$).

2.6.2.2 Gain

The step-wise regression with *Gain* as dependent variable removed from the design matrix psycho-social characteristics such as Extra/Introversion, Neuroticism and their interaction with Condition ($F < 1.68$, $p > .05$). The final mixed-effects model revealed that the Condition was significant ($F(2,1278) = 178.11$, $p < .0001$). Post-hoc analysis showed that *Gain* was systematically higher in Tight σ^* compared to Medium and Large σ^* ($t(1278) = 9.22$, $p < .0001$; $t(1278) = 18.87$, $p < .0001$), and the same was found for Medium σ^* compared to Large σ^* ($t(1278) = 9.65$, $p < .0001$).

The Intelligence factor was significant ($F(1,39) = 12.81$, $p = .001$); Raven A participants showing a higher *Gain* than Raven B ones. The interaction Condition × Intelligence was also significant ($F(2,1278) = 3.63$, $p = .03$, Fig 2.3). Post-hoc analysis revealed that Raven A had a larger *Gain* compared to Raven B in Tight σ^* ($t(66.7) = 4.42$, $p = .0003$). A trend towards significance where *Gain* is better for Raven A compared to Raven B was found in Medium σ^* ($t(66.7) = 2.65$, $p = .09$), while no differences under Large σ^* were found ($t(66.7) = 2.31$, $p > .05$). Additionally, the analysis highlighted that both Raven A and Raven B participants showed a statistically better *Gain* under Tight σ^* compared to Medium σ^* (Raven A: $t(1278) = 7.91$, $p < .0001$; Raven B: $t(1278) = 5.10$, $p < .0001$) and Large σ^* (Raven A: $t(1310) = 14.94$, $p < .0001$; Raven B: $t(1278) = 11.71$, $p < .0001$), as well as when Medium σ^* was compared to Large σ^* (Raven A: $t(1278) = 7.03$, $p < .0001$; Raven B: $t(1278) = 6.62$, $p < .0001$).

The factor Trial and its interaction with Condition were significant ($F(10,1278) = 8.23$, $p < .0001$; $F(20,1278) = 3.63$, $p < .0001$, respectively).

As described for the *SE* metric, we run a linear mixed-effects regression model for each σ^* as post-hoc control.

Analysis on Tight σ^* showed that Trial factor was significant ($F(10,400) = 6.77$, $p < .0001$). It also revealed that the second Trial was significantly different from the other 10 Trials ($t(400) > 3.69$, $p < .01$). From Trial 3, all other pairwise comparisons were nonsignificant ($t(400) < 2.58$, $p > .05$).

Analysis on Medium σ^* revealed Trial Factor was again significant ($F(10,400) = 4.81$, $p < .0001$). Post-hoc analysis also revealed that the second Trial was significantly different from Trials 5, 8, 9, 10, 11, and 12 ($t(400) > 3.29$, $p < .05$). Trial 2 was not statistically different from Trials 3, 4, and 7 ($t(400) < 3.16$, $p > .05$).

Trial 3 was significantly different from Trial 5 and 12 ($t(400) = 4.08$, $p = .003$; $t(400) = 3.50$, $p = .02$, respectively). From Trial 4, the remaining pairwise comparisons highlighted nonsignificant differences ($t(400) < 2.98$, $p > .05$).

Large σ^* analysis revealed Trial factor was significant ($F(10,40) = 3.99$, $p < .0001$). Post-hoc analysis revealed that Trial 2 is not significant from the other eleven trials ($t < 2.22$, $p > .05$). Trial 3 revealed a trend towards to significance with Trial 10 ($t(410) = 3.17$, $p = .06$), while it was not significantly different from all other trials ($t(400) < 2.83, p > .05$. Trial 4 was significantly different from Trial 11 ($t(400) = 3.88$, $p = .006$), and slightly different from Trial 12 ($t(400) = 3.11, p = .07$). A trend toward significance between Trial 4 and Trial 12 was also detected ($t(400) = 3.14, p = .06$). Trial 4 was not statistically different from the remaining Trials ($t < 2.81, p > .05$). Trials 5 and Trial 6 presented no significant differences ($t < 2.75, p > .05$). Trial 7 was instead significantly different from Trial 11 ($t(400) = 3.59, p = .02$), and the same from Trial 8 ($t(410) = 3.32$, $p = .04$). A trend toward significance was observed between Trial 9 and Trial 11 ($t(400) = 3.02, p = .09$), as well as between Trial 10 and Trials 11 and 12 ($t(400) = 4.17$, $p = .002$, $t(400) = 3.50$, $p = .02$, respectively). All the other pairwise comparisons were nonsignificant ($t < 2.90$, $p > .05$).

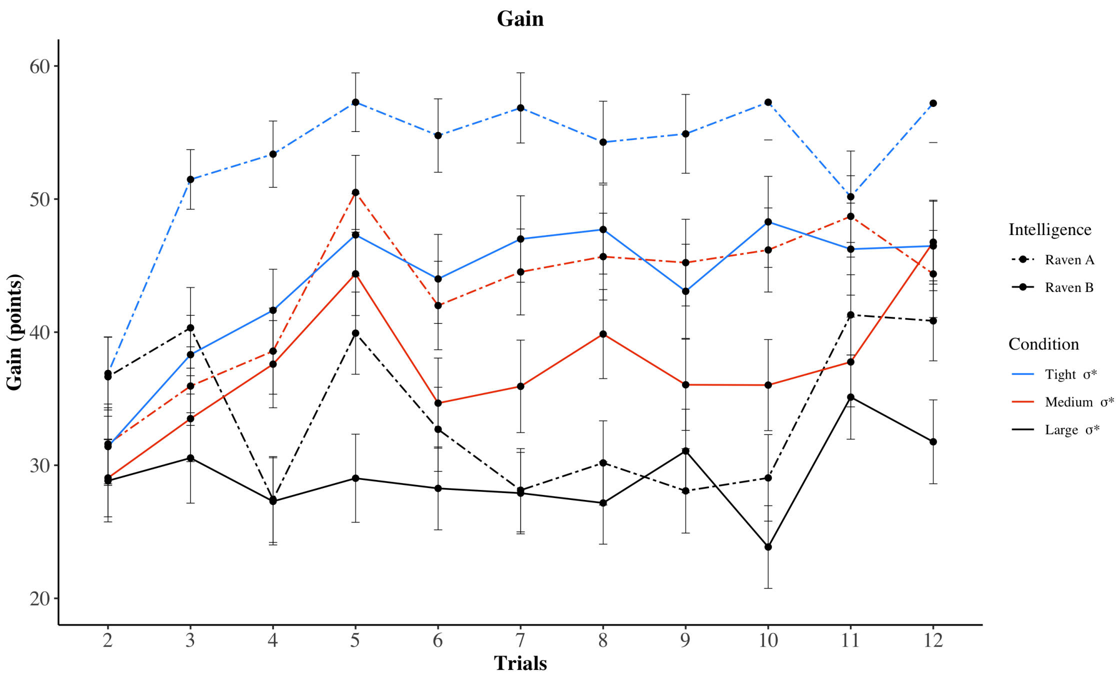


Figure 2.3: Raven A and Raven B groups Gain in the three conditions (σ^*s). *Gain* average and SEM for each trial of Raven A and B groups are reported. Fig. 2.4 shows *Gain* in the three σ^*s, separately.

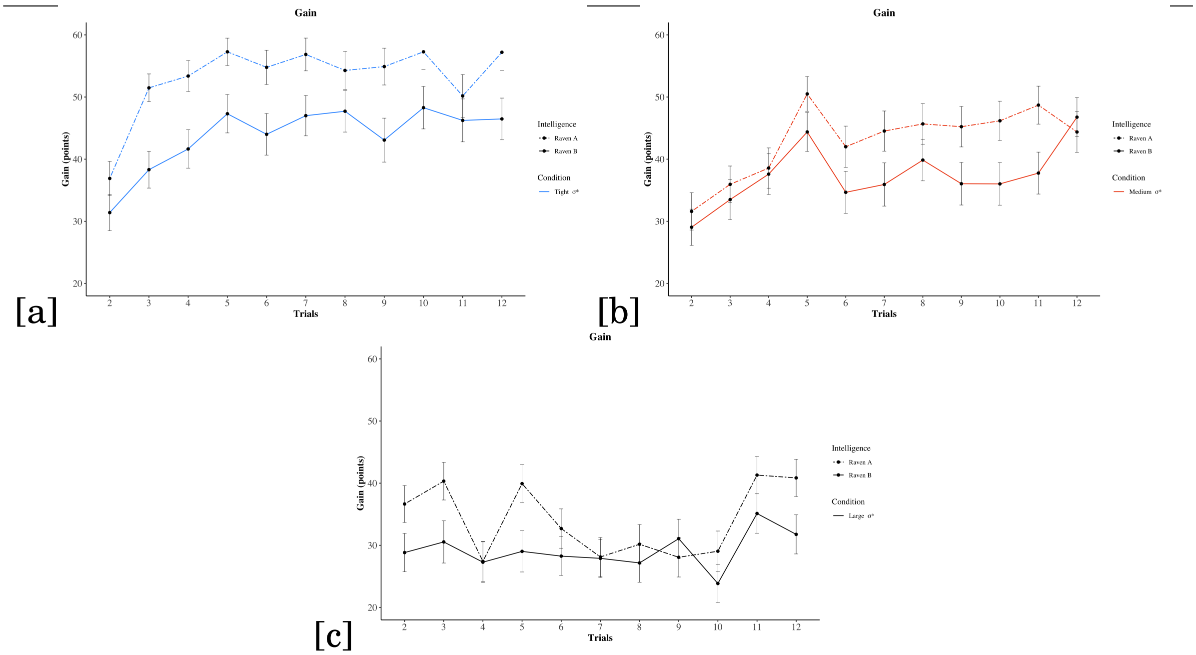


Figure 2.4: *Gain* average and SEM for each trial and for each σ^* of Raven A and Raven B groups are reported. Fig. 2.4a shows *Gain* parameter in the Tight σ^* where the uncertainty was low; Fig. 2.4b shows Gain in the Medium σ^* while Fig. 2.4c shows *Gain* in the Large σ^* which was characterised by high variability.

2.6.2.3 Gain Error

Step-wise regression revealed no differences for personality characteristics, Extra/Introversion, Neuroticism and Anxiety Trait, nor for their interaction with Condition ($F < 1.62$, $p > .05$).

Final model revealed single factor Condition was significant($F(2,1158) = 14.78$, $p < .0001$). In particular, post-hoc analysis on *Gain Error* highlighted no differences between Tight and Medium σ^* were found ($t(1158) = .76$, $p > .05$). However, a better *Gain Error* in both Tight and Medium σ^* compared to Large σ^* was found ($t(1158) = 4.28, p = .0001$; $t(1158) = 5.05$,

$p < .0001$, respectively).

Intelligence factor was significant ($F(1,39) = 13.37$, $p = .0010$) where the difference between the points gained by OUM and participants was minor for Raven A compared to Raven B group. Furthermore, its interaction with Condition factor was significant ($F(2,1158) = 3.48$, $p = .03$), Fig. 2.5). Post-hoc analysis revealed a better *Gain Error* for Raven A compared to B in Tight σ^* ($t(66.3) = 4.37$, $p = .0004$) while no differences between the two experimental groups emerged in Medium and Large σ^* ($t(66.3) = 2.63$, $p > .05$; $t(66.3) = 2.32$, $p > .05$, respectively).

Raven A people showed no differences between Tight and Medium σ^* ($t(1158) = 0.91$, $p > .05$). *GE* was better for Tight compared to Large σ^* ($t(1158) = 4.70$, $p = .0001$) and for Medium compared to Large σ^* ($t(1158) = 3.78$, $p = .01$).
In Raven B participants instead, a similar *Gain Error* between Tight and Medium σ and between Tight σ^* and Large σ^* was found($t(1158) = 2.03$, $p > .05$; $t(1158) = 1.31$, $p > .05$, respectively). However, *Gain Error* was better in Medium compared to Large σ^* ($t(1158) = 3.34$, $p > .05$).

Trial factor as well as the interaction Trial × Condition were significant ($F(10,1278) = 180.59$, $p < .0001$; $F(20,1278) = 2.40$, $p = .001$).

Linear mixed model regression for each σ^* analysis revealed that in Tight σ^* Trial factor was not significant ($F(9,360) = 0.94$, $p > .05$). Whereas Trial factor in Medium and Large σ were significant ($t(360) = 3.44$, $p = .02$; $t < 2.14$, $p > .05$), respectively).

Post-hoc analysis in Medium σ^* showed significant differences between Trial 4 and 5 ($t(360) = 3.44$, $p = .02$), while the other comparisons were nonsignificant ($t < 2.14$, $p > .05$).

In Large σ^*, Time effect was significant ($F(9, 360) = 5.81$, $p < .0001$). Post-hoc analysis revealed Trial 3 was significantly different from Trial 6 ($t(360) = 3.66$, $p = .01$), while it was not different from the other trials ($t < 1.87$, $p > .05$). Trial 4 was significantly different from Trial 6 and Trial 11 ($t(360) = 5.32$, $p < .0001$; $t(360) = 3.53$, $p = .01$, respectively). Additionally, a trend towards significant between Trial 4 and 12 was found ($t(360) = 3.11$, $p = .06$). Other comparisons for Trial 4 were not different ($t < 2.04$, $p > .05$). Trial 5 was significant different from Trial 6 ($t(360) = 5.42$, $p < .02$), but it was not different from the other trials ($t < 2.04$, $p > .05$). Trial 6 was significantly different from Trial 7, 8, 9 and 10 ($t(360) = 3.83$, $p = .001$; $t(360) = 4.49$, $p = .0004$; $t(360) = 4.33$, $p = .001$; $t(360) = 5.47$, $p < .0001$, respectively). Trial 6 was not different from trials 11 and 12 ($t < 2.22$, $p > .05$). Trial 10 was different from Trial 11 and 12 ($t(360) = 3.59$, $p = .01$; $t(360) = 3.25$, $p = .04$). The remaining comparisons were nonsignificant (t$t < 2.62$, $p > .05$).

2.6.2.4 Standard Deviation Error (SD-E)

Step-wise regression removed single factors Extra/Introversion and Neuroticism as well as their interaction with Condition. Moreover, step-wise regression removed the interaction Time × Condition ($F < 2.52$, $p > .05$).

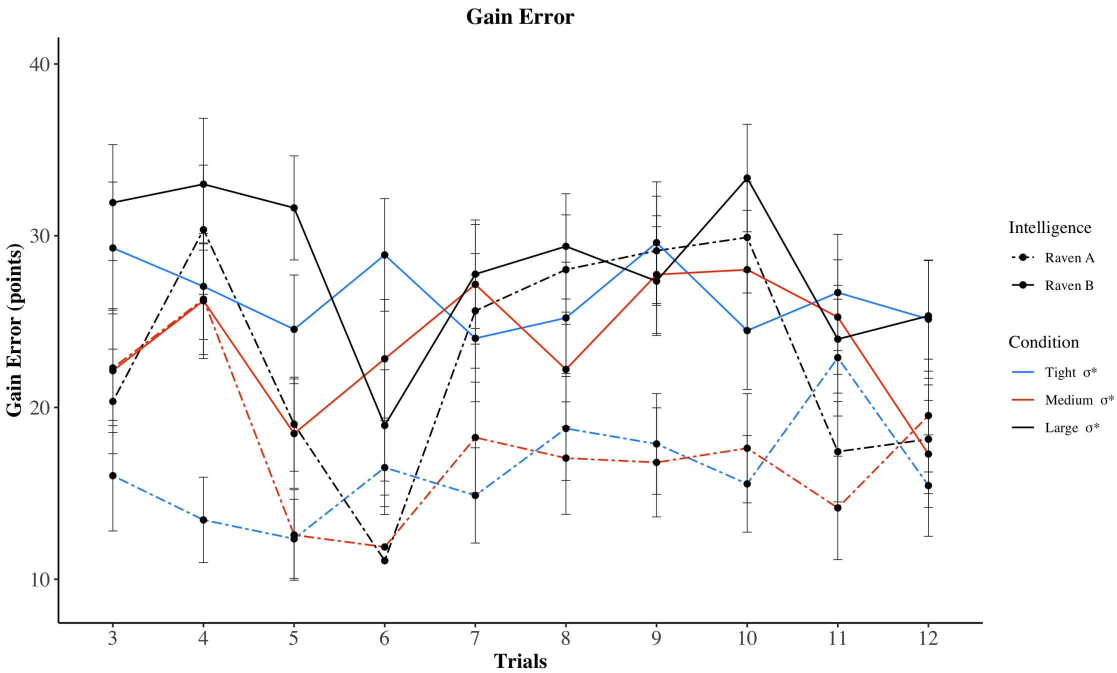


Figure 2.5: Raven A and Raven B groups *Gain Error* in the three conditions (σ^*s).*Gain Error* average and SEM for each Trial of Raven A and B groups. Fig. 2.6 shows *Gain Error* in the three σ^*s separately.

The final model analysis revealed difference among the three σ^*s ($F(2,1203) = 35.14$, $p < .0001$). In particular, the differences between the bucket length of participants and the OUM bucket length was higher in Tight σ^* compared to Medium and Large σ^* ($t(1203) = 14.67$, $p < .0001$; $t(1203) = 8.93$, $p < .0001$, respectively). Moreover, *SD-E* was better in Medium compared to Large σ^* ($t(1203) = 5.74$, $p = .001$). Single factor Intelligence and Anxiety Trait were nonsignificant ($F < 3.36$, $p > .05$). However their interaction with Condition were significant (Intelligence × Condition: F $(2,1203) = 4.044$, $p = .02$; Anxiety Trait × Condition: $F(2,1203) = 18.11$, $p < .0001$). Post-hoc analysis Intelligence × Condition revealed no-differences between the two groups in the three σ^*s ($t(1203) < 1.80$, $p > .05$, Fig. 2.7).

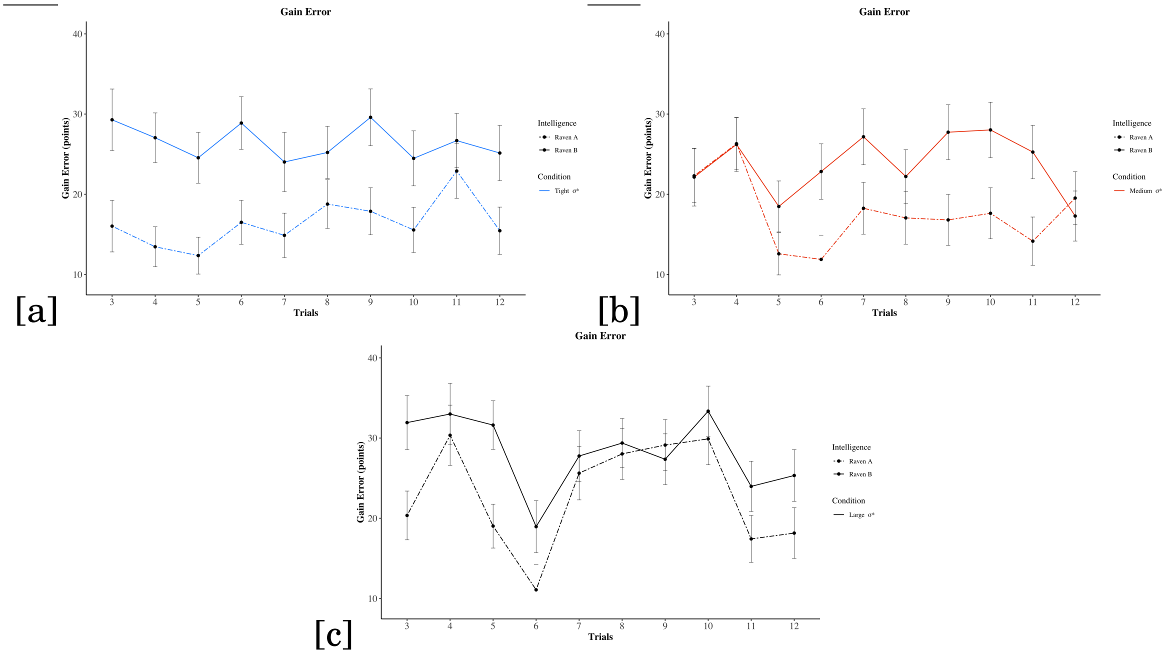


Figure 2.6: The charts report *Gain Error* average and SEM for each trial for Raven A and Raven B groups. Fig. 2.6a shows *Gain Error* parameter in the Tight σ^* where the uncertainty was low; Fig. 2.6b shows Gain Error in the Medium σ^* while Fig. 2.6c shows *Gain Error* in the Large σ^* where high variability was present.

However, post-hoc analysis reported that *SD-E* of both Raven A and B groups was better in Large compared to Tight σ^* and for Raven A participants *SD-E* was better in Large compared to Medium σ^* ($t(1203) = 15.37$, $p < .0001$). This difference was not found in Raven B participants (t (1203) = 2.50, p = .1). Additionally, post-hoc analysis revealed for both Raven A and Raven B groups better *SD-E* in Medium compared to Tight σ^* ($t(120) = 9.45$, $p < .0001$; $t(120) = 10.61$, $p < .0001$).

Post-hoc analysis on Interaction Anxiety Trait and Condition revealed no-differences between High Trait Anxiety and Low Trait Anxiety people ($t(41.4) < 2.54$, $p > .05$). However, post-hoc analysis showed that High

Anxiety group showed *SD-E* was closed to OUM in Large compared to Medium and Tight σ^* ($t(1203) = 5.18$, $p < .0001$; $t(1203) = 9.39$, $p < .0001$, respectively). Moreover, *SD-E* was more close to OUM in Medium compared to Tight σ^* ($t(1203) = 14.58$, $p < .0001$). In Low Anxiety Trait group, *SD-E* was more close to OUM in Medium compared to Large and Tight σ^* ($t(1203) = 2.77$, $p = .05$; $t(1203) = 5.68$, $p < .0001$) as well as it was close to OUM in Large compared to Tight σ^* ($t(1203) = 2.92$, $p = .03$).

Trial factor was significant ($F(9,1174) = 47.98$, $p < .0001$)). Post-hoc analysis revealed that Trial 3 was significantly worse than the other 9 trials (($t(1174) > 4.86$, $p < .05$). Trial 4 was significant different from trial 6 to 12 ($t > 4.93$, $p < .05$). No difference between trials 4 and 5 was found ($t(1174) = 2.74, p > .05$). Trail 5 was significantly different from trial 7 to 12 (($t(1174) > 5.26$, $p < .05$), but not from 6 ($t(1174) = 2.18$, $p > .05$). A trend towards significance between Trial 6 and trial 7 ($t(1174) = 3.08, p = .06$) was found. Moreover, it was significantly different from the Trials 8 to 12 ($t(1174) > 3.98$, $p < .05$). From trial 7 remaining pairwise comparisons were nonsignificant ($t(1174) < 1.12$, $p > .05$).

2.6.2.5 Bucket length σ^U

Step-wise regression removed personality characteristics, Extra/Introversion and Neuroticism and their interaction with Condition ($F < 1.01$, $p > .05$).

The final model revealed significant differences among the three σ^*s

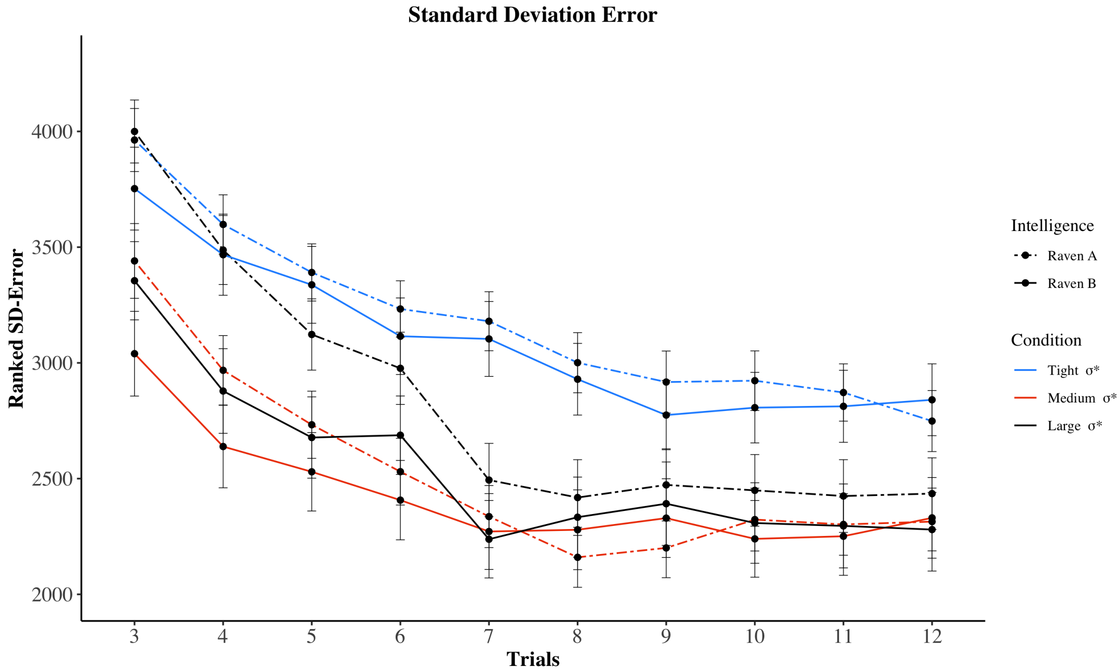


Figure 2.7: Raven A and Raven B groups SD-E (Eq. 1.3) in the three conditions (σ^*). The chart reports the *SD-E* ranked average and SEM for each Trial of Raven A and Raven B groups by Condition. In Fig. 2.8 it is possible to view *SD-E* in the three σ^*s separately.

($F(2,1156) = 163.34$, $p < .0001$). In particular, participants had a shorter bucket in Tight σ^* compared Medium and Large σ^* ($t(1156) = 7.49$, $p < .0001$; $t(1156) = 17.99$, $p < .0001$, respectively). Moreover, the bucket was shorter in Medium compared to Large σ^* ($t(1156) = 10.50$, $p < .0001$).

Single factor Intelligence was not significant ($F(1,38) = 0.25$, $p > .05$) while its interaction with Condition was ($F(2,1156) = 8.442$, $p < .0001$, Fig. 2.9). Post-hoc analysis revealed no-differences between Raven A and Raven B participants in all three σ^*s ($t(39.9) < .1.04, p > .05$).

Both Raven A and B participants modulated differently the bucket

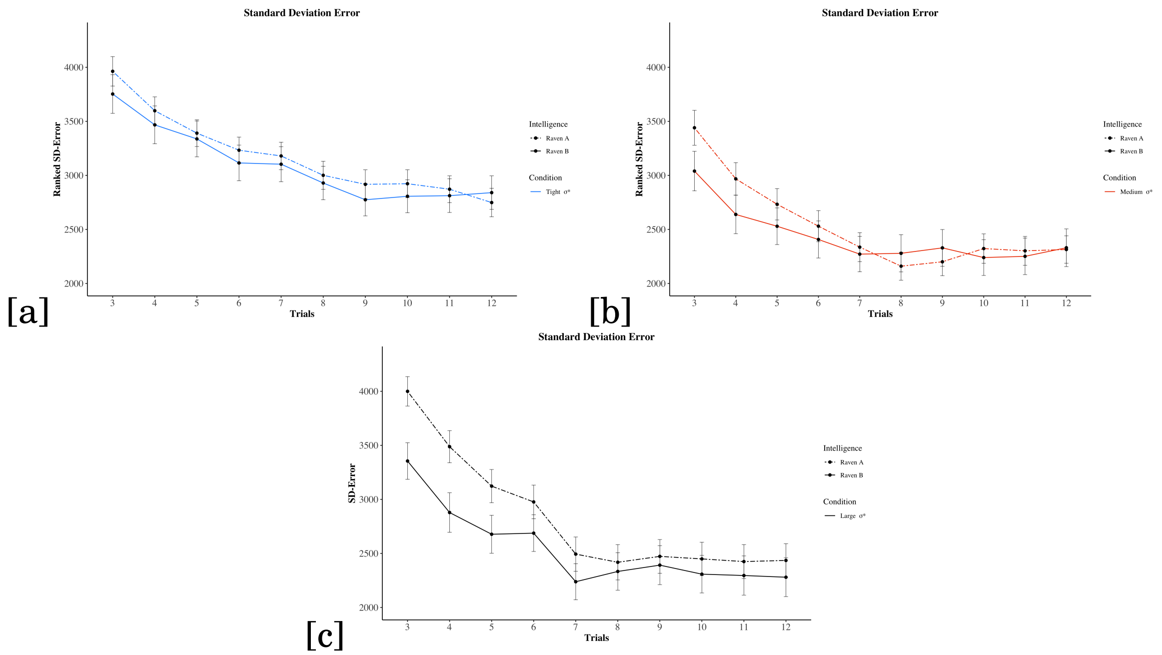


Figure 2.8: The charts reported the ranked *SD-E* average and SEM for each Trial of Raven A and B groups by Condition. Fig. 2.8a shows *SD-E* parameter in the Tight σ^* where the uncertainty was low; Fig. 2.8b shows SD-E in the Medium σ^* while Fig. 2.8c shows *SD-E* in the Large condition where high variability was present.

according to the σ^*s. Specifically, in Tight σ^* both the experimental groups had a shorter bucket compared to Medium and Large σ^* (Raven A: $t(1156) = 6.61$, $p < .0001$; Raven B: $t(1156) = 3.74$, $p = .002$; Raven A: ($t(1156) = 1.03$, $p < .0001$; Raven B: $t(1310) = 9.89$, $p < .0001$). Moreover, the bucket of the two groups was shorter in Medium compared to Large σ^* (Raven A: $t(1156) = 8.42$, $p < .0001$; Raven B: $t(1156) = 6.14$, $p < .0001$).

Trial factor ($t(1156) = 17.94$, $p < .0001$) and its interaction with Condition ($F(18, 1156) = 6.55$, $p < .0001$) were significant. A linear mixed-effects model regression for each σ^* was performed.

In Tight σ^*, Trial factor was significant ($F(10, 400) = 43.72$, $p < .0001$).

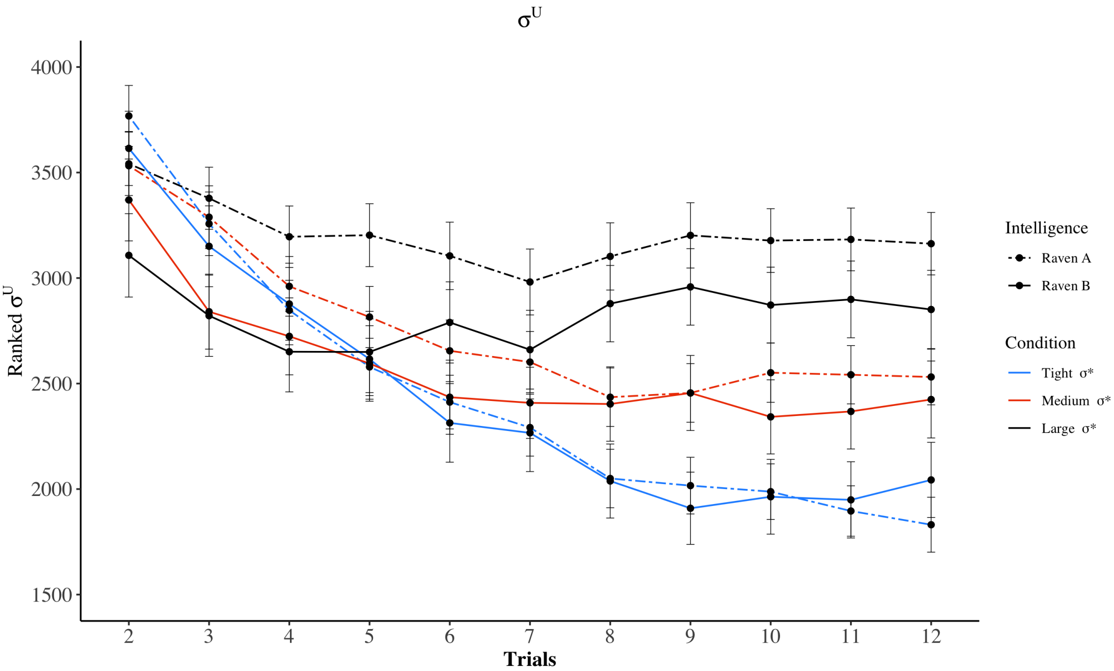
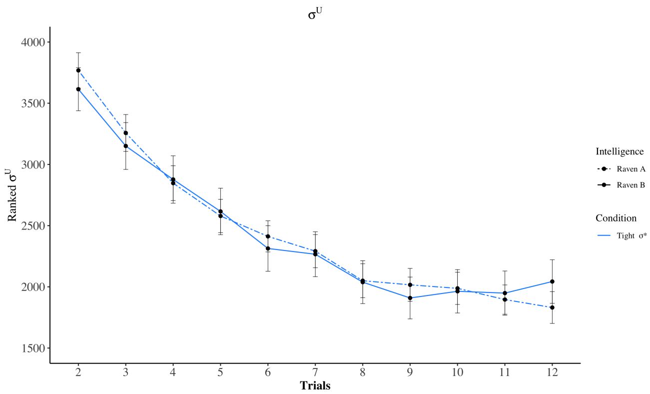


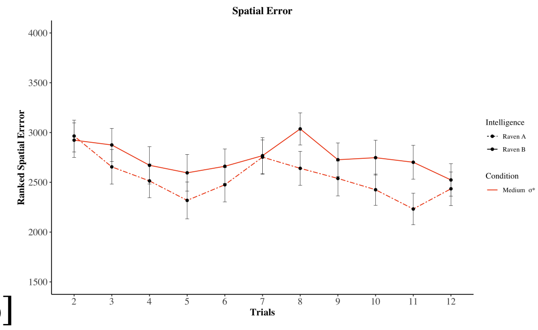
Figure 2.9: Raven A and Raven B σ^U in the three conditions (σ^*s). The chart reports the ranked σ^U average and SEM for each Trial of Raven A and B groups. Fig. 2.10 shows σ^U in the three σ^*s, separately.

The post-hoc analysis highlighted that Trial 2 was significantly different from the other eleven trials ($t(400) > 3.37$, $p < .05$). Trial 3 was significantly different from the others trials ($t(400) > 4.45$, $p < .05$) except from Trial 4 ($t(400) = 2.33$, $p > .05$). Trial 4 was different from the other trials ($t(400) > 4.30$, $p < .05$) except for trial 5 ($t(400) = 2.15$, $p > .05$). Trial 5 was different from trials 8 to 12 ($t(400) > 4.70$, $p < .05$), but not from trials 6 and 7 ($t < 2.87$, $p > .05$).

Trial 6 was different from trials 9 to 12 ($t(400) > 3.72$, $p < .05$) but not from trials 7 and 8 ($t < 2.52$, $p > .05$). From Trial 7, comparisons were nonsignificant ($t < 3.08$, $p > .05$).



[a]



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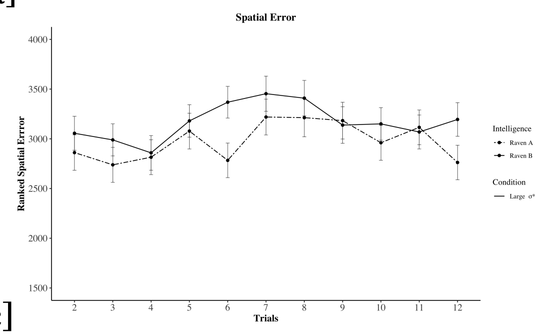

[c]

Figure 2.10: Ranked σ^U average and SEM for each Trial for the three σ^*s are reported. In particular, Fig. 2.10a shows σ^U parameter in Tight σ^* where the uncertainty was low; Fig. 2.10b shows σ^U in Medium σ^* while Fig. 2.10c shows σ^U in the Large condition where high variability was present.

In Medium σ^* Trial factor was significant ($F(10,400) = 16.26$, $p < .0001$). Post-hoc analysis revealed that Trial 2 was significantly different from Trials 4 to 12 ($t(400) > 4.44$, $p < .05$). However, it was not different from Trial 3 ($t(400) = 2.61$, $p > .05$). Trial 3 was different from Trial 6 to 12 ($t(400) > 4.85$, $p < .05$). Moreover a trend towards significant between Trial 3 and 5 was found ($t(400) = 3.05$, $p = .07$). No differences between Trial 3 and Trial 4 were found (($t(400) = 1.83$, $p > .05$). Trial 4 was significantly different from trials 7 to 12 ($t(400) > 3.48$, $p < .05$), while no differences emerged between Trial 4 and 5 and between trial 4 and 6 ($t(400) < 3.02$,

$p > .05$). From Trial 5, the other comparisons were nonsignificant ($t < 2.98$, $p > .05$).

A trend toward significance was found in Large σ^* ($F(10,400) = 1.74$, $p = .07$). Post-hoc analysis revealed differences between trial 2 and Trial 7 ($t(400) = 3.73$, $p = .01$). All other remaining comparisons were nonsignificant ($t < 2.73$, $p > .05$).

2.7 Discussion and Conclusion

In the decision processes, participants should reduce the uncertainty selecting and integration the information given by the environment. However, this process is not straightforward because people need to balance winnings and losses. Moreover, due to the inferential nature of the process, personality characteristics such as intelligence and personality traits could modulate the decision process. For instance, high intelligence could help in mastering the dynamic environment better than normally intelligent ones (Gonzalez et al., 2005). Nevertheless, also personal traits may also tune decision making (Byrne et al., 2015; Khalil, 2016; Lauriola and Levin, 2001; Tao et al., 2020): extroversion tends to drive towards utilitarian decisions (Tao et al., 2020), while neuroticism and high anxiety lead to less risky behaviour (Khalil, 2016).

In the present study, we analysed the role played by both intelligence and personality characteristics on the way people adapt in a probabilistic decision task.

This allowed us to understand which confounding factors should be involved in the next studies on sport athletes.

Accounting for the ability to adapt to environmental uncertainty, fluid intelligence, but not personality traits, emerged to have a role, as highly intelligent participants showed better *SE*, *Gain* and *Gain Error*. At the same time, the deeper analysis revealed that all these parameters were higher in intelligent participants but just when the environmental uncertainty was low (Tight σ^*); when it increased, the differences among the participants disappeared.

The analysis on the bucket length (σ^U) showed that all participants decreased the length proportionally to the level of uncertainty (σ^*) by witnessing that participants understood the presence of the three environmental levels of uncertainty. Moreover, time effect analysis revealed that the bucket was modulated across trials in Tight and Medium σ^* while the time effect was not present in Large σ^*. Again, the analysis showed that neither intelligence nor personality traits have a role in such modulation.

The analysis on the ability to set the best bucket length as a function of the level of uncertainty participants were exposed to every time (*SD-E*) showed that no differences emerged as a function of either participants' intelligence or personality traits.

However, the analysis showed also that participants have larger *SD-E* in the Tight condition than in both Medium and Large ones, where the bucket length was larger than the optimal (Sub-chapter 1.3.1.3).

All things considered, our research indicated that intelligence supports people's in maximising task-related gains via probabilistic decision-making processes.

Actually, the constraints featuring the role of intelligence role are twofold. The first one entails that intelligence supports only the optimal spatial localisation of the events to happen: for what concerns the other factors involved in the performance, such as the bucket length setting, intelligence does not exert any impact. The second constraint is related to the level of uncertainty people can manage: when the events' distribution is higher than a certain threshold, intelligence cannot influence task-related spatial analysis and responses. Our results indicated that both groups followed a similar strategy. However, highly intelligent participants seemed to be better able to compute the average of the events compared to normally intelligent people, but only in Tight σ^* and this also led to a better maximisation of the score. This could be due to better information integration; probably, intelligent participants were able to update their internal model about the environment more efficiently than normally intelligent participants. Furthermore, it is possible to assume that intelligent participants can store more information than normally and less intelligent people in our task. Indeed, it is well known the association between high intelligence and high working-memory span (Engle et al., 1999).

Moreover, our results in *SD-E* and σ^U analysis are very interesting. As previously said, all participants, in each condition, modulate the bucket length similarly. Moreover, they modulated the bucket according to the uncertainty seen. However, when the Users' bucket length was compared to an Optimal Decision Maker (OUM - Sub-chapter 1.3.1.3), in the Tight condition, the bucket length was larger than necessary while in the other two conditions, the bucket length modulation was close to the OUM.

It is known that people can compute implicitly probabilistic decisions, (Clark, 2013) as well as they, are able to create and update their internal model about an environment (Nassar et al., 2016; O'Reilly et al., 2013) to maximise the gain. Thus, it is possible to assume that participants could know how to set the bucket in order to collect as many points as possible. This is particularly true when participants encountered Medium and Large conditions, while when participants faced the low uncertainty environment, this part of the probabilistic process did not work properly. This probably occurred because they could not be completely aware that they could exploit more this specific condition. These results could be supported by the fact that contrarily to the other conditions in which participants were forced to enlarge the bucket to collect dots and points, in Tight σ^*, they had the feedback that they are collecting points; thus, they could not understand how to set the bucket to maximise the score. Thus, it is possible to assume that participants had a lower awareness/implicit confidence, consequently bringing a lower risk tasking (Kepecs et al., 2008). Another complementary possibility is the possible loss aversion. According to Prospect Theory, (Kahneman and Tversky, 1979) in which the authors postulated that losses are more significant than the pleasure to gain, it is possible that participants, when they faced the low uncertainty environment, they gave more importance to collect points than to maximise the score with risk of lost points. Indeed, to perform optimally in Tight condition, participants, together with the ability to compute the running average of the dots' direction, should set the bucket length very Tight (about 18°) without considering the possibility to miss some dots given by unexpected events.

Regarding personality traits results, it is possible to notice that our participants were healthy people. None of them suffered from any clinical disorder; thus, in non-clinical conditions, personality traits did not seem to affect the probabilistic decision. For instance, a recent experiment (Vaghi et al., 2017) that employed a similar task to ours revealed that obsessive-compulsive patients were not able to store all information as healthy people did. However, the metacognition process was similar to healthy participants. Thus, for the next future investigation, participants with clinical disorders should be recruited to better understand whether and how personality traits modulate decision-making processes.

All things considered, our research indicated that intelligence supports people's in maximising task-related gains via probabilistic decision-making processes. Actually, the constraints featuring the role of intelligence role are twofold. The first one entails that intelligence supports only the optimal spatial localisation of the events to happen: for what concerns the other factors involved in the gain, the bucket length setting, intelligence does not exert any impact. The second constraint is related to the level of uncertainty people can manage: when the events' distribution is higher than a certain threshold, intelligence cannot influence task-related spatial analysis and responses. Furthermore, these results indicated loss aversion behaviour or less implicit confidence when participants faced the low uncertainty environment than when the uncertainty was high.

The present study allowed us to understand which confounding factors to control in Study 2 and Study 3 (Chapter 3 and Chapter 4, respectively). Thus, in these two experiments, we controlled fluid intelligence (Raven and Court, 1998; Raven). Regarding the possible improvements and future studies, they are discussed in Chapter 5.

CHAPTER 3

General Perceptual Decision Ability in Young Athletes of Open- and Closed-Skills Sports - Study 2

3.1 Introduction

Sport practice in childhood is important not only for the prevention of some chronic diseases such as obesity and diabetes, but also to increase cognitive function (Zhu et al., 2014). Several meta-analyses, systematic and literature reviews have tried to summarise the copious investigations' results (Biddle and Asare, 2011; Biddle et al., 2019; de Greeff et al., 2018).

Substantially, these manuscripts have shown that physical activity and sport practice can increase children's cognitive functions even if some studies reported a general inconsistency of the results. Moreover, several investigations have focused on whether the type of activity and/or type of sport (e.g., open- and closed-skill, Chapter 1) modulates the cognitive function differently in the last years (Pesce et al., 2009).

As reported in Chapter 1, open-skill athletes such as football and tennis players are required to adapt themselves to the mutable situations of the game. In contrast, closed-skill athletes such as swimmers and runners compete in quite stable situations. However, much research investigated the basic cognitive function, while only a few investigations analysed the high-order cognitive functions such as problem-solving, reasoning and decision-making (de Greeff et al., 2018). This is especially true when young athletes are involved in the studies. In fact, there are only some studies that investigated general decision-making ability in young athletes. Specifically, a quite recent study investigated young football players' decision-making ability where comparisons of different roles (e.g. forward and defensive players) were performed. The study highlighted forward players had more risky behaviour than defensive players because a mistake of the defensive players could produce a high risk to concede a goal, while in forward areas, a mistake of forwarding players could produce a loss of ball possession substantially (Gonzaga et al., 2014).

Thus, the present study aimed at filling this lack through the investigations of generic decision-making skills of young athletes who used to practice open- and closed-skill sports. In particular, our attention was focused on decision-making under uncertainty (Berger, 1989). Specifically, the statistical decision task described in Sub-chapter 1.3.1 was employed. According to some investigation (Kayhan et al., 2019), also very young children seemed to be able to create an internal model of statistical environments to perform well. Thus, given the fact that also in developmental age children are able to produce inferential thinks, we hypothesised the expertise acquired in a specific sport domain could help in the process of developing an internal model to exploit the environment properly.

Specifically, we hypothesised for all participants differences in the three conditions (Fig. 1.1) in *Spatial Error* (*SE*), *Gain* and σ^U. No differences among the three σ^*s in *SD-E* and *Gain Error* were expected because participants should maintain a similar distance to the OUM (ref. 1.3.1.3). Additionally, differences between young open- and closed-skill sports athletes were hypothesised. In particular, given the nature of open-skill sports, where the environment is constantly changing compared to closed-skill sports (Gu et al., 2019; Russo and Ottoboni, 2019; Voss et al., 2010), we assumed better decision performance in open- compared to closed-skill athletes. Specifically, we hypothesised that young open-skill athletes should be able to find the optimal position about the direction of the dots (*Spatial Error*) compared to closed-skill athletes. This could be due to the better information processing that should be characterised by open-skill sport athletes. This should consequently lead to better *Gain* and *Gain Error*.

However, we did not expect differences between the two groups in *SD-E* and σ^U because both groups should be able to understand the environment and should be able to understand how to set the bucket length. As reported in Study 1 and Study 2 (Chapter 2 and Chapter 3, respectively), due to the possibility that the decision-making process is mediated by fluid intelligence (Del Missier et al., 2012; Gonzalez et al., 2005; Vostroknutov et al., 2018), it was controlled through Raven-CPM task (Raven).

3.2 Methods

3.2.1 Participants

In this study we recruited youth open- and closed-skill sport athletes. Open-skill group (OSG) consisted of football players of a professional Football Club (e.g., Venezia F.C.), while closed-skill group (CSG) consisted of track-field athletes coming from a semi-professional track-field Association. In particular, 23 football players (M_{age} = 10.65, SD_{age} = 0.49 years old) and 13 track-field athletes (M_{age} = 11.69, SD_{age} = 1.60 years old) participated in the experiment.

Additionally, in order to study the effect of intelligence on the task, the sample was divided according to Raven-CMP score. Specifically, participants were divided into highly intelligent participants (Raven A) and normally intelligent ones (Raven B) using the median of the sample (score = 29).

Linear regression analysis on Raven-CPM score was performed to test the possible differences between the two groups. No differences between the two experimental groups emerged ($F(1,33) = 0.04$, $p > .05$).
The study was approved by the Ethic Committee of University of Bologna (Fig. A.2). Participants' parents filled the informed consent to participate in the study (see Fig. A.5). Moreover, information about the experiment was given to the pupils.

3.2.2 Procedure

The procedure was similar to Study 1 procedure (2.4) in which athletes performed the decision task and Raven-CPM task (Raven, 1958). Participants performed both tasks in a quiet location.
Unlike adults, young athletes completed the Raven-CPM task Raven (Sub-chapter 1.3.2.2) in which pre-adolescent have to choose among six possibilities. In the decision task, participants were told to earn as many points as possible. To do that, participants could move along the circumference and modulate the bucket length, where the larger the bucket, the smaller the win (see Sub.chapter 1.3.1 and Fig. 1.2).

3.2.3 Data Analysis

Data analysis was performed through R Software (R Core Team, 2013) with RStudio (RStudio Team, 2015). Data was analysed as panel data;

thus, we created a linear mixed-effects regression model (Bates et al., 2015) with Trial factor as fixed time effects. The independent variables were: Condition (σ^*, 3 levels), Type of Sport (2 levels: OSG *vs* CSG), Intelligence (2 levels; Raven A *vs* Raven B) and Trial (Time effect, 11 or 10 levels). Whereas, the dependent variables were *Spatial Error*, *Gain*, *Gain Error*, *SD-Error* and σ^U and were analysed separately.

Data recorded from the task were analysed in the following way: for the *Spatial Error*, *Gain*, and σ^U, the first trial after the beginning of a new condition of dots throw was removed from the analysis as well as trials after the 12^{th} were removed in order to have balanced numerosity of each trial (i.e., 11 trials for each participant were analysed). Furthermore, in *Gain Error* and *SD-E* even the second trial was removed from the analysis because both human and OUM (Sub-chapter 1.3.1.3) were not able to estimate the standard deviation of throws direction. Data of *SE*, *SD-Error* and σ^U were rank transformed to reduce the non-normality and the heteroskedasticity of the data.

When necessary, post-hoc analysis was performed. Moreover, we run a step-wise regression analysis for each dependent variable to achieve the most significant final model.

3.3 Results

3.3.1 Statistical Decision Task

3.3.1.1 Spatial Error (SE)

Step-wise regression analysis on the linear mixed-effects regression model on *SE* revealed that intelligence and its interaction with the Condition factor were nonsignificant ($F < 2.11$, $p > .05$).

The final model showed the single factor Condition was significant ($F(2,1086) = 45,31$, $p < .0001$) and post-hoc analysis revealed participants were able to computed the running average of the dot directions better in Tight σ^* compared to Medium and Large σ^* ($t(1086) = 7.50$, $p < .0001$; $t(1086) = 8.83$, $p < .0001$). However, no-differences between Medium and Large σ^* were found ($t(1086)1.33$, $p = .38$).

Single factor Type of Sport was significant ($F(1,33) = 6.94$, $p = .01$) where OSG had a better *SE* than CSG. In addition interaction Type of Sport × Condition was significant ($F(2,1086) = 5.84$, $p = .003$, Fig. 3.1). Post-hoc analysis revealed better *SE* in OSG compared to CSG in Tight σ^* ($t(42) = 3.44$, $p = .01$), while no differences emerged in Medium and Tight σ^* ($t(42) = 2.55$, $p = .013$; $t(42) = 1.45$, $p > .05$, respectively). Additionally, post-hoc analysis revealed that *SE* of both the groups was better in Tight compared to Medium and Large σ^* (OSG: $t(1086) = 7.40$, $p < .0001$; CSG: $t(1086) = 3.77$, $p = .002$; OSG: $t(1086) = 10.04$, $p < .0001$; CSG: $t(1086) = 3.42$, $p = .01$, respectively). Moreover, data analysis revealed a trend to significant between Medium and Large σ^* ($t(1086) = 2.64$, $p = .075$) in OSG, while no differences between Medium and Large σ^* in CSG were found ($t(1086) = 0.35$, $p > .05$; see Fig. 3.1).

Trial effect was significant ($F(10, 1086) = 17.64$, $p < .0001$) as well as

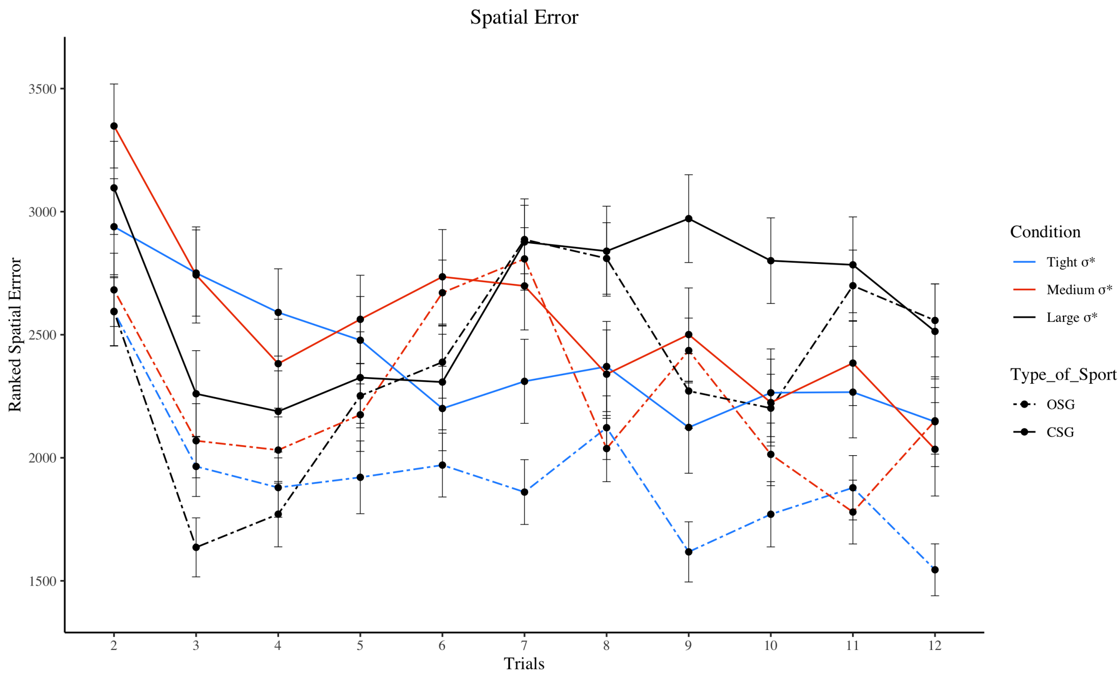

Figure 3.1: The figure shows OSG and CSG ranked *Spatial Error* in the three conditions (σ^*). The chart reports ranked *SE* average and SEM for each trial and for each σ^* of CSG and OSG. Fig. 3.2 shows *SE* in the three σ^*s separately.

interaction Trial × Condition ($F(20, 1086) = 9.89$, $p < .0001$). Post-hoc analysis in interaction Trial × Condition was conducted with three separate analysis due to the difficulty of *EMMEANS* package (Lenth et al., 2018) to process the great amount of interactions.

In Tight, Medium and Large σ^* Trial factor was significant ($F(10, 340) = 9.57$, $p < .0001$; $F(10, 340) = 13.85$, $p < .0001$; $F(10, 340) = 16.43$, $p <$

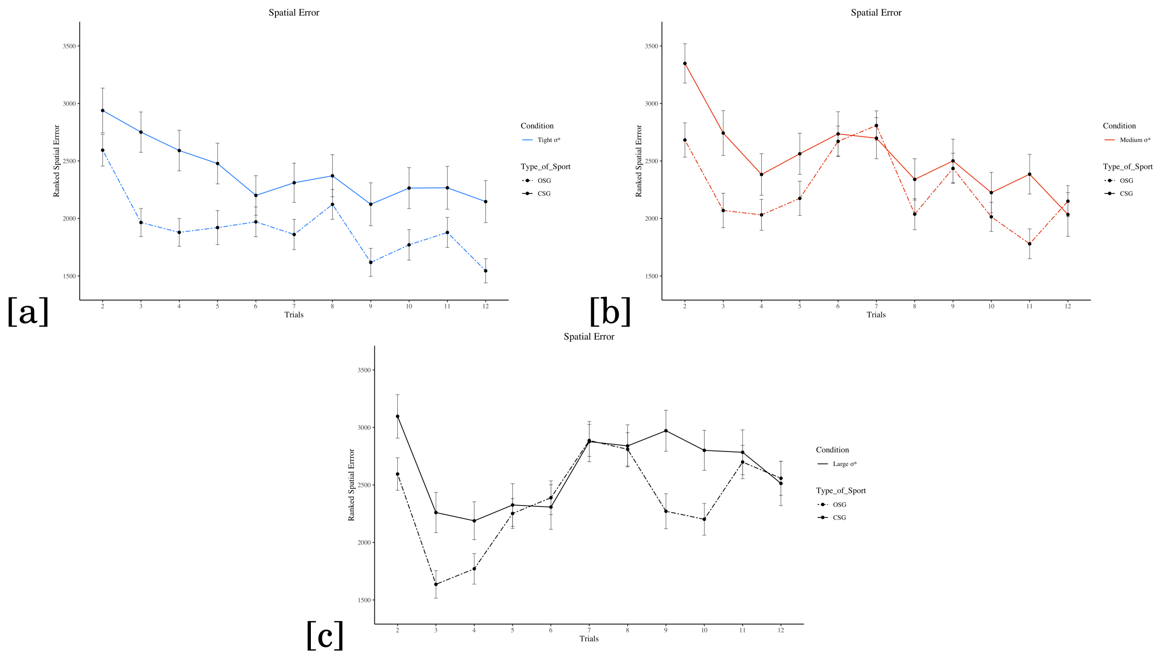

Figure 3.2: Fig. 3.2a shows *SE* (Eq. 1.1) in the Tight σ^* where the uncertainty was low; Fig. 3.2b *SE* shows the Medium σ^* while Fig. 3.2c shows *SE* in the condition that was characterisedby high variability (Large σ^*.

.0001). Post-hoc analyses are reported in Table 3.1, Table 3.2 and Table 3.3 in Supplemental Information Chapter (Sub-chapter 3.5).

3.3.1.2 Gain

Step-wise regression revealed Intelligence and its interaction were non-significant ($F <= 2.59$, $p > .05$).

The final model revealed Condition was significant ($F(2,1086) = 97.18$, $p < .001$). Post-hoc analysis revealed that participants were able to collect more points in Tight σ^* compared to Medium and Large σ^* ($t(1086) = 10.14$, $p < .0001$; $t(1086) = 13.36$, $p < .0001$, respectively) as well as *Gain* was higher in Medium compared to Large σ^* ($t(1086) = 3.21$, $p = .004$).

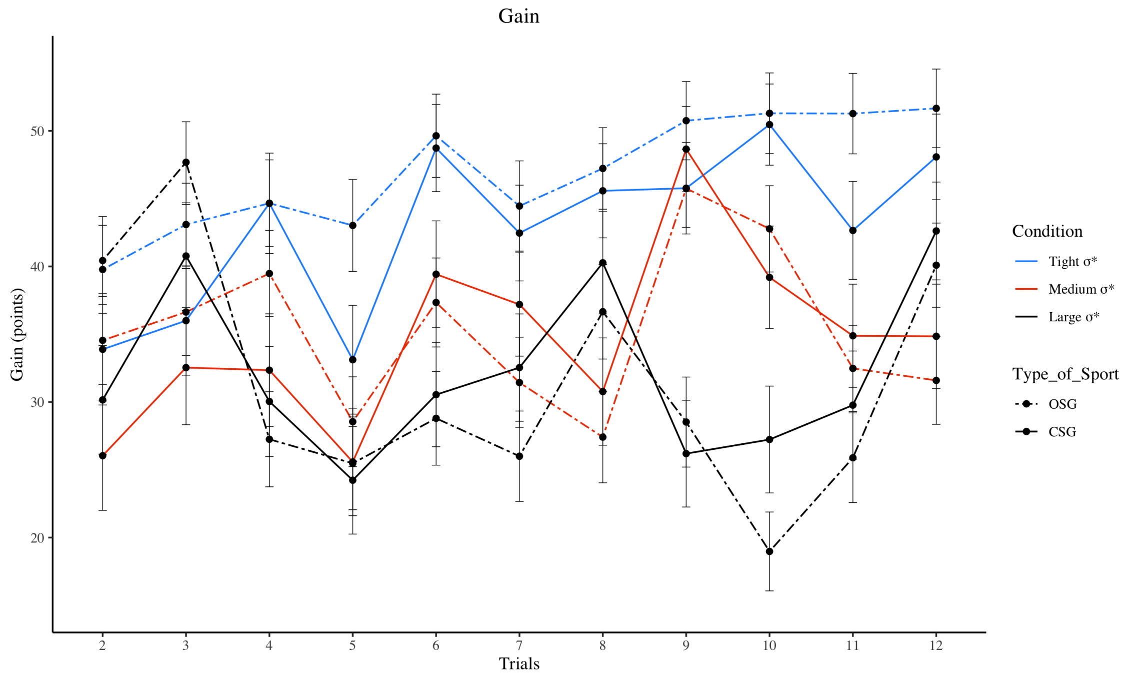

Figure 3.3: The figure shows OSG and CSG *Gain* in the three conditions (σ^*s). The chart reports *Gain* average and SEM for each trial of CSG and OSG. In Fig. 3.4 it is possible to view *Gain* in the three σ^*s separately.

Single factor Type of Sport was not significant ($F(1,33) = 0.34$, $p < .0001$). However, its interaction with Condition was significant ($F(2,1086) = 3.34$, $p = .04$, Fig. 3.3). Post-hoc analysis did not reveal any differences between OSG and CSG in the three σ^*s (tight σ^*: $t(51.8) = 1.64$, $p > .05$; Tight σ^*: $t(51.8) = 0.24$, $p > .05$; Large σ^*: $t(51.8) = 0.31$, $p > .05$). However, both the groups were able to collect more points in Tight σ^* compared to Tight (OSG: $t(1086) = 9.80$, $p < .0001$; CSG: $t(1806) = 5.26$, $p < .0001$) and Large σ^* (OSG: $t(1086) = 13.01$, $p < .0001$; CSG: $t(1086) = 6.84$, $p < .0001$). Moreover, OSG was able to collect more points in Tight compared to Large σ^* ($t(1086) = 3.21$, $p = .01$). However, this did not happen for CSG ($t(1086) = 1.59$, $p > .05$).

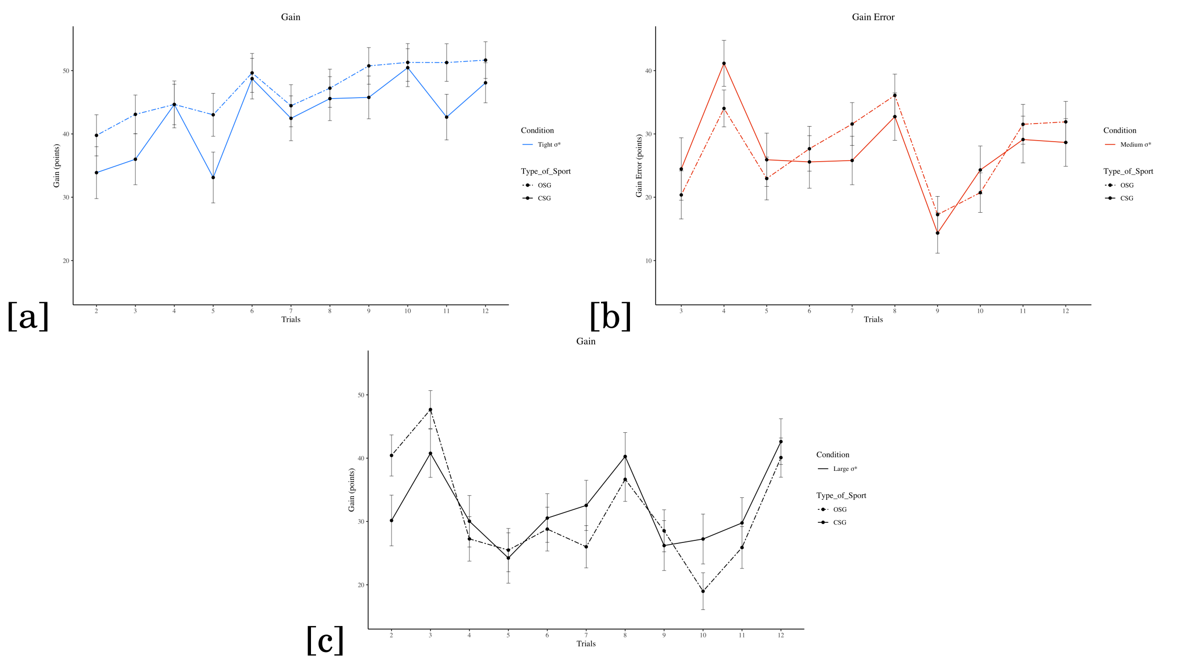

Figure 3.4: *Gain* average and SEM for each trial and for each σ^* of CSG and OSG are reported. Fig. 3.4a shows *Gain* parameter in the Tight σ^* where the uncertainty was low; Fig. 3.4b shows *Gain* in Medium σ^* while Fig. 3.6c shows *Gain* in the Large condition which was characterised by high variability.

In Tight, Tight and Large σ^* Trial factor was significant ($F(10,340) = 4.96$, $p < .0001$; $F(10,340) = 6.63$, $p < .0001$; $F(10,340) = 10.55$, $p < .001$, respectively). Post-hoc analyses are reported in Table 3.4, 3.5 and 3.6 of Supplemental Information Chapter (Chapter 3.5).

3.3.1.3 Gain Error

Step-wise regression removed Intelligence factor and its interaction with Condition ($F < 2.48$, $p > .05$).

Final linear mixed-effect regression model revealed that Condition factor was significant ($F(2,984) = 16.44$, $p < .0001$). Post-hoc analysis revealed that participants were close to OUM (1.3.1.3) in Tight compared to Medium σ^* ($t(984) = 5.70$, $p < .0001$) as well as they were more close to OUM (1.3.1.3) in Large compared to Medium σ^* ($t(984) = 3.97$, $p = .0002$). Whereas, no-differences between Tight and Large σ^* emerged ($t(984) = 1.73$, $p > .05$).

Single factor Type of Sport was not significant ($F(1,33) = 0.77$, $p > .05$) while its interaction with Condition was significant ($F(2,984) = 4.45$, $p = .01$, Fig. 3.5).

Post-hoc analysis revealed no-differences between the two experimental groups in the three conditions were found (Tight σ^*: $t(53.3) = 1.69$, $p > .05$; Medium σ: $t(53.3) = 0.041$, $p > .05$; Large σ^*: $t(53.3) = 0.61$, $p > .05$). Moreover, post-hoc analysis revealed CSG's *Gain Error* in Tight and Medium σ^* was similar ($t(984) = 2.23$, $p > .05$) as well no-differences between Tight and Large σ^* were found ($t(985) = 0.72$, $p > .05$). Whereas the *Gain Error* was better in Medium compared to Large σ^* ($t(984) = 2.05$, $p > 1$). OSG instead, had a better *Gain Error* in Tight compared to Medium σ^* ($t(984) = 6.45$, $p < .0001$) and *Gain Error* was better in Tight compared to Large σ^* ($t(984) = 3.77$, $p = .002$). A trend to significant where *Gain Error* was better compared to Large σ^* was found ($t(984) = 2.68$, $p = .067$).

Trial factor was significant ($F(9,984) = 6.26$, $p < .0001$) as well as its interaction with Condition ($F(18,984) = 9.96$, $p < .0001$). As performed in the previous analysis. Three separate linear mixed regression models for each σ^* were performed to analysis the time effect. In Tight, Medium and Large

σ^* Trial factor was significant ($F(9,306) = 4.51$, $p < .0001$; $F(9,308) = 8.97$, $p < .0001$; $F(9,306) = 14.09$, $p < .0001$, respectively). Post-hoc analyses are reported in Table 3.7, 3.8 and 3.9 of Supplemental Information Chapter (Sub-chapter 3.5.3).

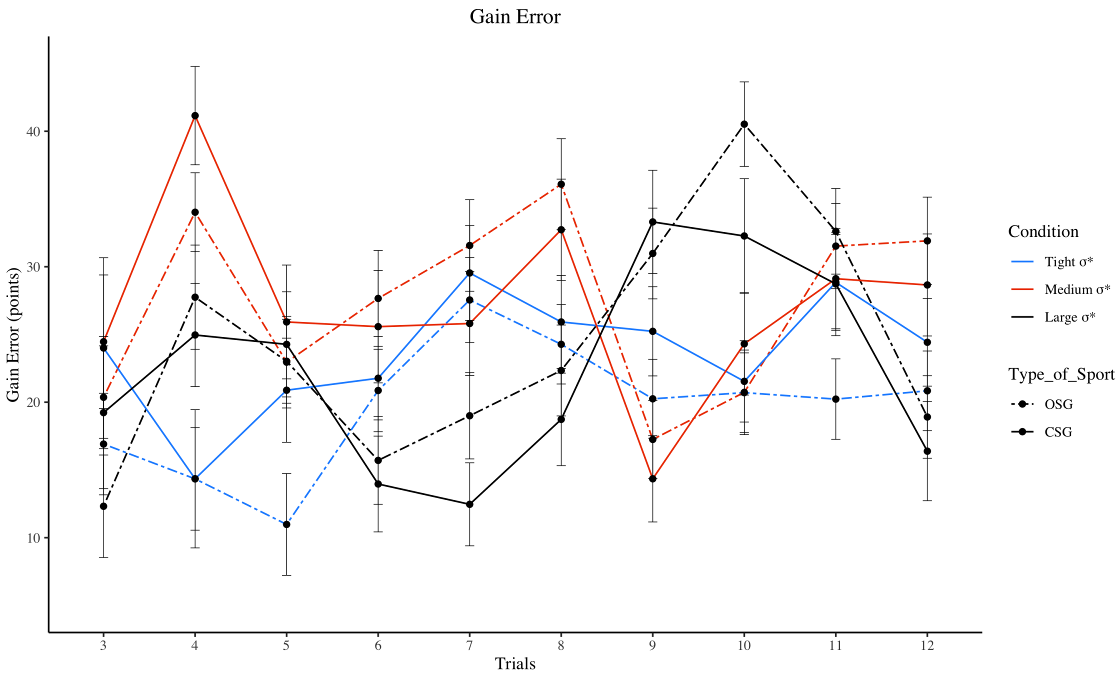

Figure 3.5: The figure shows OSG and CSG *Gain Error* in the three conditions (σ^*). The charts reported *Gain Error* average and SEM for each Trial of CSG and OSG. In Fig. 3.6 it is possible to view *Gain Error* in the three σ^*s separately.

3.3.1.4 *Standard Deviation Error (SD-E)*

Step-wise regression on linear mixed-effects regression model on *SD-E* (Eq. 1.3) revealed single factor Condition was significant ($F(2,982) = 331.85$, $p < .0001$). Post-hoc analysis highlighted that *SD-E* was better in Medium compared to tight σ^* and Large σ^* ($t(982) = 14.71$, $p < .0001$;

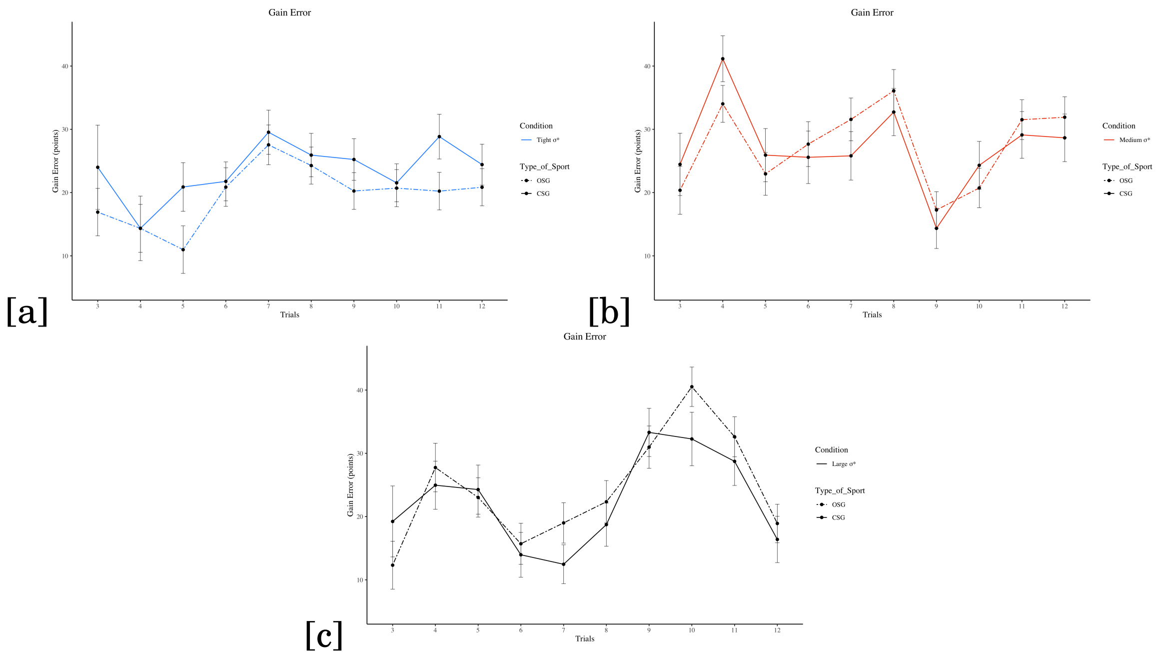

Figure 3.6: *Gain Error* average and SEM for each trial for CSG and OSG are reported. Fig. 3.6a shows *Gain Error* parameter in the Tight σ^* where the uncertainty was low; Fig. 3.6b shows *Gain Error* in the Medium σ^* while the Fig. 3.6c shows *Gain Error* in the Large σ^* where high variability was present.

$t(982) = 10.97$, $p < .0001$). Moreover, *SD-E* was better in Large compared to the tight σ^* ($t(982) = 10.97$, $p < .0001$). Single factor Type of Sport was significant and *SD-E* was better in OSG compared to CSG ($t(32) = 4.39$, $p = .0001$). Also the interaction Type of Sport × Condition was significant ($F(2,982) = 6.96$, $p = .001$, Fig. 4.12). Post-hoc analysis revealed better *SD-E* for OSG compared to CSG in all three σ^*s (tight $\sigma*$: $t(36.3) = 5.06$, $p = .0001$; Medium σ^*: $t(36.3) = 3.46$, $p = .01$; Large σ^*: $t(36.3) = 4.24$, $p = .001$). Additionally, both the groups had different *SD-E* among the three conditions. Specifically, both the groups had a better *SD-E* in Large compared to Medium (OSG: $t(982) = 10.50$, $p < .0001$; CSG:

$t(982) = 5.77$, $p < .0001$) and tight σ^* (OSG: $t(982) = 19.51$, $p < .0001$; CSG: $t(982) = 17.39$, $p < .0001$). Furthermore, *SD-E* was better in Medium compared to tight σ^* (OSG: $t(982) = 10.50$, $p < .0001$; CSG: $t(982) = 11.62$, $p < .0001$).

Single factor Intelligence was not significant ($F(1,32) = 0.46$, $p > .05$), but its interaction with Condition was significant ($F(2,982) = 4.32$, $p = .01$). Post-hoc analysis revealed no-differences between Raven A and Raven B in the three σ^*s (tight σ^*: $t(36.3) = 1.37$, $p > .05$; Medium σ^*: $t(36.3) = 0.42$, $p > .05$; Large σ^*: $t(36.3) = 0.17$, $p > .05$). Both the groups had a better*SD-E* in Large σ^* compared to Medium (Raven A: $t(982) = 8.45$, $p < .0001$; Raven B: $t(982) = 7.35$, $p < .0001$) and tight σ^* (Raven A: $t(982) = 20.78$, $p < .0001$; Raven B: $t(982) = 16.22$, $p < .0001$). Moreover, *SD-E* was better in Medium compared to tight σ^* (Raven A: $t(982) = 12.34$, $p < .0001$; Raven B: $t(982) = 8.88$, $p < .0001$).

Trial factor ($F(9,982) = 147.02$, $p < .0001$) as well as its interaction with Condition ($F(18,982) = 8.42$, $p < .0001$) were significant.

In order to analyse the time effect, as performed in the previous analysis we analysed the Trial factor for each σ^*. In tight, Medium and Large σ^* single factor Trial was significant ($F(306) = 4.43$, $p = .0006$; $F(9,306) = 56.66$, $p < .0001$; $F(9,306) = 8.68$, $p < .0001$, respectively). Post-hoc analyses are reported in Table 3.10, 3.12 and 3.6 of Supplemental Information Chapter (Chapter 3.5, Sub-chapter 3.5.4).

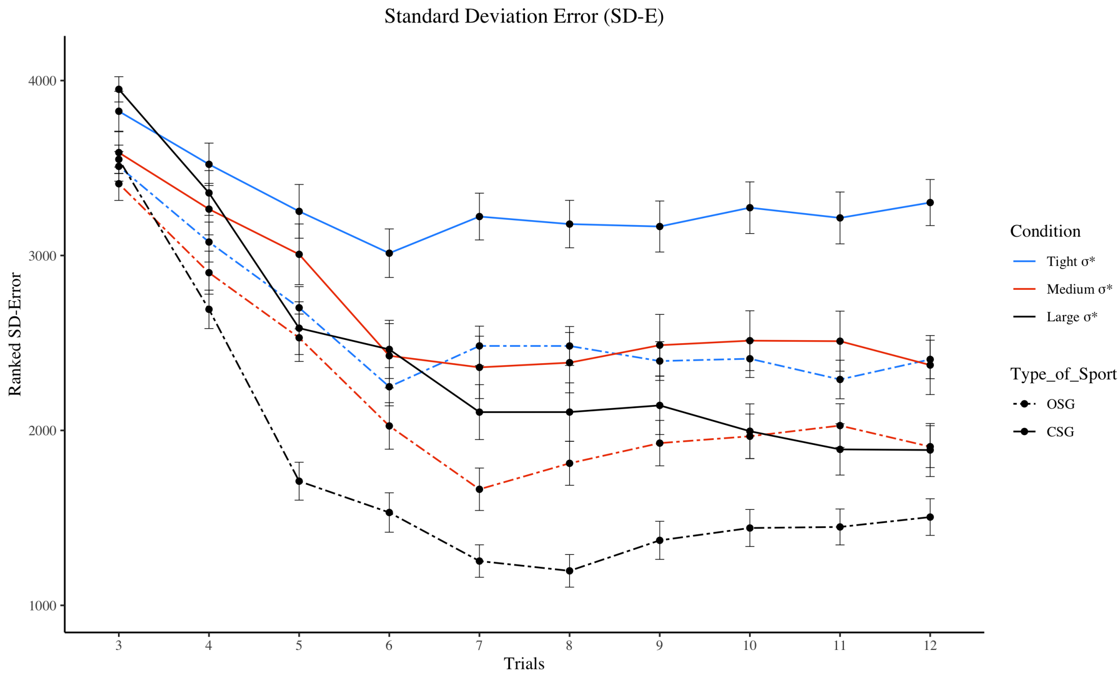

Figure 3.7: OSG and CSG *SD-E* (Eq. 1.3) in the three conditions (σ^*). The chart reports the ranked *SD-E* average and SEM for each Trial of OSG and CSG. Fig. 4.13 shows the ranked *SD-E* average and SEM in the three σ^*s separately.

3.3.1.5 *Bucket length* (σ^U)

Step-wise regression removed Intelligence factor and its interaction with Condition ($F < 1.51$, $p > .05$). Moreover, interaction Condition × Trial was removed from the final regression model ($F(20, 1086) = 1.21$, $p > .05$). The final linear mixed-effect regression model revealed the single factor Condition was significant ($F(2, 1106) = 11.97$, $p < .0001$). Post-hoc analysis revealed that bucket length was shorter in tight compared to Medium and Large σ^* ($t(1106) = 4.87$, $p < .0001$; $t(1106) = 2.91$, $p = .01$, respectively). However, no differences between Medium and Large σ^* were found ($t(1106) = 1.96$, $p = .12$). Single factor Type of Sport ($F(1, 1106) = 19.70$,

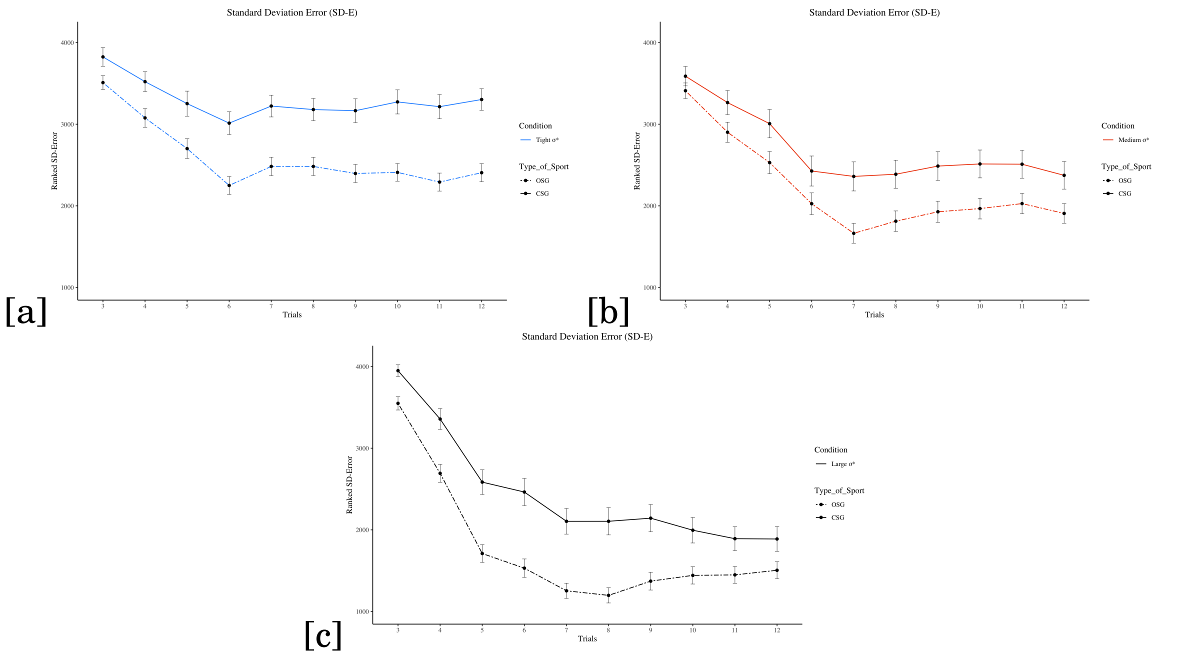

Figure 3.8: In the charts reported the *SD-E* ranked average and SEM for each Trial of OSG and CSG. Fig. 4.13a shows *SD-E* parameter in tight σ^* where the uncertainty was low; Fig. 4.13b shows *SD-E* in Medium σ^*, while Fig. 4.13c shows *SD-E* in the Large condition where high variability was present.

$p < .0001$), where the OSG's bucket length was shorter compared to CSG's bucket length, and Interaction Type of Sport × Condition were significant ($F(2,1106) = 16.98$, $p < .0001$, Fig. 3.10). Post-hoc analysis revealed that in the three σ^*s OSG had a shorter bucket compared to CSG (tight σ^*: $t(36.5) = 5.20$, $p = .0001$; Medium σ^*: $t(36.5) = 3.54$, $p = .04$; Large σ^*: $t(36.5) = 4.73$, $p = .0003$).

Furthermore, post-hoc analysis on σ^U of CSG revealed that it was similar among three σ^*s (tight σ^* *vs* Medium σ^*: $t(1106) = 0.43$, $p > .05$; tight σ^* *vs* Large σ^*: $t(1106) = 1.06$, $p > .05$; Medium σ^* *vs* Large σ^*: $t(1.49$, $p > .05$). Whereas, analysis on OSG revealed a shorter bucket in tight com-

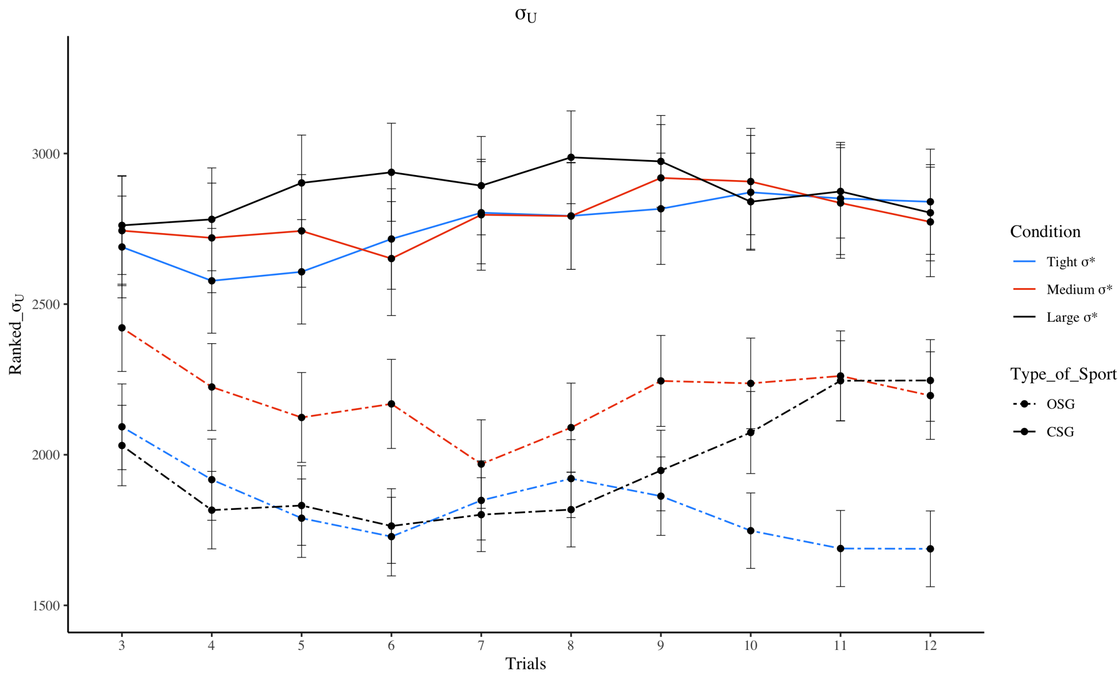

Figure 3.9: Figure shows OSG and CSG σ^U in the three conditions (σ^*s). The chart reports the σ^U ranked average and SEM for each Trial of CSG and OSG. Fig. 3.10 shows σ^U in the three σ^*s, separately.

pared to Medium and Large σ^* ($t(1106) = 8.54$, $p < .0001$; $t(1106) = 3.39$, $p = .007$). Additionally, analysis showed σ^U was shorter in Large compared to Medium σ^* ($t(1106) = 5.15$, $p < .0001$).

Single factor Trial was significant ($F(10, 1106) = 2.71$, $p = .003$). Post-hoc analysis revealed Trial 2 was significantly different from trials 4, 5, 6, 7 ($t(1106) > 3.29$, $p < .05$). A trend to significance when compared to Trial 8 was found ($t(1106) = 3.17$, $p = .06$). No differences in the remaining comparisons with Trial 2 were found ($t < 2.59$, $p > .06$). From Trial 3 all remaining comparisons were not significant ($t < 2.62$, $p > .05$).

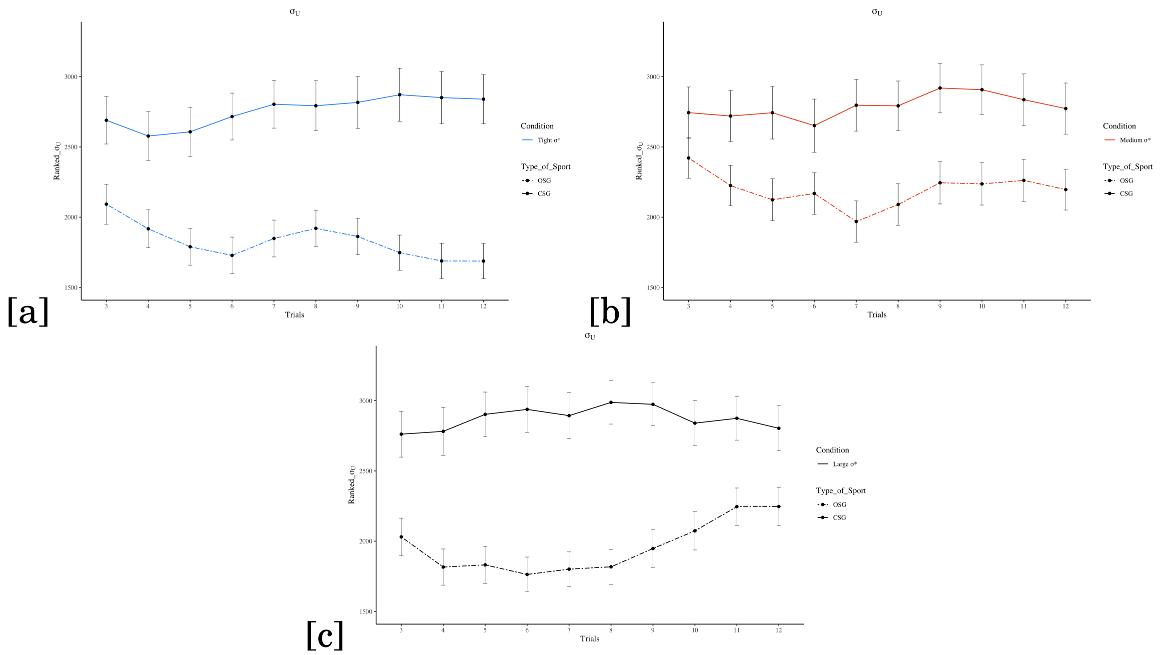

Figure 3.10: Ranked σ^U ranked average and SEM for each Trial for the three σ^*s are reported. In particular, Fig. 3.10a shows σ^U parameter in tight σ^* where the uncertainty was low; Fig. 3.10b shows σ^U in Medium σ^* while the Fig. 3.10c shows σ^U in the Large condition where high variability was present.

3.4 Discussion and Conclusion

Physical and sport activities in childhood could lead to physiological and psychological benefits. For example, it is known that active children in their adulthood are less risky to develop metabolic and cardiac diseases (Zhu et al., 2019). Moreover, it improves some cognitive function. Thus, the practice of physical activity or sport activities can increase the general well-being of people (Biddle and Asare, 2011; Paluska and Schwenk, 2000). However, in the last years, researchers have been trying to examine the role of different activities on cognitive function (i.e., Pesce et al. 2009), such as open and closed skill activities. However, most investigations analysed the low order cognitive function, while high-order cognitive functions such as problem-solving, reasoning and decision-making are less examined (Biddle and Asare, 2011). Thus, in this research, decision-making skills of èlite pre-adolescents that used to practice open- or closed-skill sports were analysed. Furthermore, open- and closed-skill athletes were chosen because the type of sport activity could change the behaviour differently (Gu et al., 2019). For instance, open skills athletes play their match in very dynamic environments while closed skills athletes compete in a quite stable environment. Thus, the open-skill sport practice could enhance more high-order cognitive function than closed skill sport activities.

Decision-making skills were analysed through a statistical decision task (Sub-chapter 1.3.1) in which participants had to adapt themselves to an uncertain environment. Specifically, the aim of the task was to adapt to uncertain situations in order to collect as many points as possible.

We hypothesised that open-skill athletes should have a better performance than closed skill athletes. This should be true for *SE* and *Gain* and *Gain Error*. In contrast, no-differences should be recorded in *SD-E* and σ^U because they should modulate the bucket length in a similar way. Moreover, in order to control the possible differences between open and closed skills sports were given due to cognitive function as observed in Study 1 and in Study 3 (Chapter 2 and Chapter 4, respectively), fluid intelligence was controlled. Results highlighted that fluid intelligence did not affect any of the parameters of the task. However, *SE* performance was affected by the type of sport practised. In particular, results highlighted that open-skill athletes were better able to compute the running mean of events compared to closed- Skill athletes, but this was true when the environment was more predictable. Nonetheless, this better ability did not lead to a better *Gain*, *Gain Error* and *SD-E*. Moreover, the results showed, as found in Study 1 and Study 3 (Chapter 2 and Chapter 4, respectively), participants widened the bucket more than necessary when the low uncertainty was present. Thus, even in this case, it is possible to assume that when participants faced high uncertainty environments, they seemed to be forced to widen the bucket and thus they were close to OUM compared to tight σ^*. Indeed, when the uncertainty was low pre-adolescents did not seem aware of the possibility to increase the *Gain*. Or as explained in the previous chapter, the possibility of losing some dots was more important than increasing the score (Kahneman and Tversky, 1979). Moreover, our results on interaction Condition × Type of Sport on σ^U and *SD-E* indicated that closed-skill sport athletes did not modulate the bucket according to the uncertainties as open-skill athletes did. Thus, our results suggest that open skill athletes seem to be better able to understand these uncertain environments compared to closed skill athletes. Probably they are able to create a more accurate internal model of this statistical environment.

However, contrarily to what happened in Study 1 (Chapter ,2) the accurate internal model of OSG did not lead to a better *Gain*. These results could be explained with the linear pay-off matrix involved in the task (see Sub-chapter 5.0.2 in Chapter 5), which could not allow to completely understand participants performance. Another possible explanation could be due to the different attentional skills of open and closed skill athletes. In the latter hypothesis, open skill athletes are able to spread their attention to several pieces of information, while the closed skills athletes could focus their attention on salient information (Pesce Anzeneder et al., 1998; Pesce and Bosel, 2001).

According to this explanation, open-skill athletes are able to focus their attention on both score and direction of events, while closed- Skill athletes directed their attention only to the score gained. Indeed, our instructions were to gain as many points as possible. Indeed, during a match, open skill athletes have to focus their attention on different information, and consequently, they have to create an internal model of environments to maximise the performance, while closed skill athletes should be focused only on the aim of competition.

To conclude, based on the cognitive theory of training transfer, it is reasonable to postulate that the practice of open-skill sport in developmental age could have ramifications toward sport-unrelated scenarios (Catrambone and Holyoak, 1989; Wagner, 2006; Goldstone and Sakamoto, 2003).

3.5 Supplemental Information

In the following section are reported Trial fixed effect for *Spatial Error*, *Gain*, *Gain Error*, *SD-Error* and σ_U for each σ^*.

3.5.1 *Spatial Error*

Below the Trial Analysis on *SE* for each σ^*.

Table 3.1: *SE* Trial contrast analysis in tight σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	79.9143	17.2175	340	4.641	0.0003
2 - 4	85.2286	17.2175	340	4.950	0.0001
2 - 5	70.2857	17.2175	340	4.082	0.0027
2 - 6	102.6857	17.2175	340	5.964	<.0001
2 - 7	100.3143	17.2175	340	5.826	<.0001
2 - 8	80.2286	17.2175	340	4.660	0.0002
2 - 9	135.2857	17.2175	340	7.857	<.0001
2 - 10	112.2571	17.2175	340	6.520	<.0001
2 - 11	106.1143	17.2175	340	6.163	<.0001
2 - 12	139.3714	17.2175	340	8.095	<.0001
3 - 4	5.3143	17.2175	340	0.309	1.0000
3 - 5	-9.6286	17.2175	340	-0.559	1.0000
3 - 6	22.7714	17.2175	340	1.323	0.9644
3 - 7	20.4000	17.2175	340	1.185	0.9838
3 - 8	0.3143	17.2175	340	0.018	1.0000
3 - 9	55.3714	17.2175	340	3.216	0.0538
3 - 10	32.3429	17.2175	340	1.878	0.7310
3 - 11	26.2000	17.2175	340	1.522	0.9118
3 - 12	59.4571	17.2175	340	3.453	0.0258
4 - 5	-14.9429	17.2175	340	-0.868	0.9987
4 - 6	17.4571	17.2175	340	1.014	0.9952
4 - 7	15.0857	17.2175	340	0.876	0.9986
4 - 8	-5.0000	17.2175	340	-0.290	1.0000
4 - 9	50.0571	17.2175	340	2.907	0.1250

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Table 3.1 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
4 - 10	27.0286	17.2175	340	1.570	0.8939
4 - 11	20.8857	17.2175	340	1.213	0.9807
4 - 12	54.1429	17.2175	340	3.145	0.0661
5 - 6	32.4000	17.2175	340	1.882	0.7289
5 - 7	30.0286	17.2175	340	1.744	0.8115
5 - 8	9.9429	17.2175	340	0.577	1.0000
5 - 9	65.0000	17.2175	340	3.775	0.0086
5 - 10	41.9714	17.2175	340	2.438	0.3459
5 - 11	35.8286	17.2175	340	2.081	0.5918
5 - 12	69.0857	17.2175	340	4.013	0.0035
6 - 7	-2.3714	17.2175	340	-0.138	1.0000
6 - 8	-22.4571	17.2175	340	-1.304	0.9677
6 - 9	32.6000	17.2175	340	1.893	0.7213
6 - 10	9.5714	17.2175	340	0.556	1.0000
6 - 11	3.4286	17.2175	340	0.199	1.0000
6 - 12	36.6857	17.2175	340	2.131	0.5561
7 - 8	-20.0857	17.2175	340	-1.167	0.9856
7 - 9	34.9714	17.2175	340	2.031	0.6272
7 - 10	11.9429	17.2175	340	0.694	0.9998
7 - 11	5.8000	17.2175	340	0.337	1.0000
7 - 12	39.0571	17.2175	340	2.268	0.4581
8 - 9	55.0571	17.2175	340	3.198	0.0568
8 - 10	32.0286	17.2175	340	1.860	0.7426
8 - 11	25.8857	17.2175	340	1.503	0.9180
8 - 12	59.1429	17.2175	340	3.435	0.0274
9 - 10	-23.0286	17.2175	340	-1.338	0.9616
9 - 11	-29.1714	17.2175	340	-1.694	0.8377
9 - 12	4.0857	17.2175	340	0.237	1.0000
10 - 11	-6.1429	17.2175	340	-0.357	1.0000
10 - 12	27.1143	17.2175	340	1.575	0.8919
11 - 12	33.2571	17.2175	340	1.932	0.6961

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 3.2: *SE* Trial contrast analysis in medium σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	66.9429	19.3358	340	3.462	0.0251
2 - 4	110.1429	19.3358	340	5.696	<.0001
2 - 5	100.7143	19.3358	340	5.209	<.0001
2 - 6	37.9714	19.3358	340	1.964	0.6742
2 - 7	38.3429	19.3358	340	1.983	0.6610
2 - 8	131.3429	19.3358	340	6.793	<.0001
2 - 9	93.1429	19.3358	340	4.817	0.0001
2 - 10	142.5143	19.3358	340	7.370	<.0001
2 - 11	155.1429	19.3358	340	8.024	<.0001
2 - 12	142.0286	19.3358	340	7.345	<.0001
3 - 4	43.2000	19.3358	340	2.234	0.4822
3 - 5	33.7714	19.3358	340	1.747	0.8101
3 - 6	-28.9714	19.3358	340	-1.498	0.9197
3 - 7	-28.6000	19.3358	340	-1.479	0.9259
3 - 8	64.4000	19.3358	340	3.331	0.0381
3 - 9	26.2000	19.3358	340	1.355	0.9580
3 - 10	75.5714	19.3358	340	3.908	0.0053
3 - 11	88.2000	19.3358	340	4.561	0.0004
3 - 12	75.0857	19.3358	340	3.883	0.0058
4 - 5	-9.4286	19.3358	340	-0.488	1.0000
4 - 6	-72.1714	19.3358	340	-3.733	0.0100
4 - 7	-71.8000	19.3358	340	-3.713	0.0107
4 - 8	21.2000	19.3358	340	1.096	0.9910
4 - 9	-17.0000	19.3358	340	-0.879	0.9985
4 - 10	32.3714	19.3358	340	1.674	0.8478
4 - 11	45.0000	19.3358	340	2.327	0.4177
4 - 12	31.8857	19.3358	340	1.649	0.8598
5 - 6	-62.7429	19.3358	340	-3.245	0.0494
5 - 7	-62.3714	19.3358	340	-3.226	0.0523
5 - 8	30.6286	19.3358	340	1.584	0.8882
5 - 9	-7.5714	19.3358	340	-0.392	1.0000
5 - 10	41.8000	19.3358	340	2.162	0.5338
5 - 11	54.4286	19.3358	340	2.815	0.1568
5 - 12	41.3143	19.3358	340	2.137	0.5518
6 - 7	0.3714	19.3358	340	0.019	1.0000
6 - 8	93.3714	19.3358	340	4.829	0.0001

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Table 3.2 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
6 - 9	55.1714	19.3358	340	2.853	0.1430
6 - 10	104.5429	19.3358	340	5.407	<.0001
6 - 11	117.1714	19.3358	340	6.060	<.0001
6 - 12	104.0571	19.3358	340	5.382	<.0001
7 - 8	93.0000	19.3358	340	4.810	0.0001
7 - 9	54.8000	19.3358	340	2.834	0.1498
7 - 10	104.1714	19.3358	340	5.387	<.0001
7 - 11	116.8000	19.3358	340	6.041	<.0001
7 - 12	103.6857	19.3358	340	5.362	<.0001
8 - 9	-38.2000	19.3358	340	-1.976	0.6661
8 - 10	11.1714	19.3358	340	0.578	1.0000
8 - 11	23.8000	19.3358	340	1.231	0.9786
8 - 12	10.6857	19.3358	340	0.553	1.0000
9 - 10	49.3714	19.3358	340	2.553	0.2779
9 - 11	62.0000	19.3358	340	3.206	0.0553
9 - 12	48.8857	19.3358	340	2.528	0.2919
10 - 11	12.6286	19.3358	340	0.653	0.9999
10 - 12	-0.4857	19.3358	340	-0.025	1.0000
11 - 12	-13.1143	19.3358	340	-0.678	0.9999

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 3.3: *SE* Trial contrast analysis in large σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	151.0571	19.7770	340	7.638	<.0001
2 - 4	139.0571	19.7770	340	7.031	<.0001
2 - 5	112.4286	19.7770	340	5.685	<.0001
2 - 6	61.2571	19.7770	340	3.097	0.0755
2 - 7	10.0571	19.7770	340	0.509	1.0000
2 - 8	-15.2857	19.7770	340	-0.773	0.9995
2 - 9	29.1714	19.7770	340	1.475	0.9271
2 - 10	79.2571	19.7770	340	4.008	0.0036
2 - 11	19.0000	19.7770	340	0.961	0.9969

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Table 3.3 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
2 - 12	48.5429	19.7770	340	2.455	0.3355
3 - 4	-12.0000	19.7770	340	-0.607	0.9999
3 - 5	-38.6286	19.7770	340	-1.953	0.6814
3 - 6	-89.8000	19.7770	340	-4.541	0.0004
3 - 7	-141.0000	19.7770	340	-7.130	<.0001
3 - 8	-166.3429	19.7770	340	-8.411	<.0001
3 - 9	-121.8857	19.7770	340	-6.163	<.0001
3 - 10	-71.8000	19.7770	340	-3.630	0.0143
3 - 11	-132.0571	19.7770	340	-6.677	<.0001
3 - 12	-102.5143	19.7770	340	-5.184	<.0001
4 - 5	-26.6286	19.7770	340	-1.346	0.9598
4 - 6	-77.8000	19.7770	340	-3.934	0.0048
4 - 7	-129.0000	19.7770	340	-6.523	<.0001
4 - 8	-154.3429	19.7770	340	-7.804	<.0001
4 - 9	-109.8857	19.7770	340	-5.556	<.0001
4 - 10	-59.8000	19.7770	340	-3.024	0.0924
4 - 11	-120.0571	19.7770	340	-6.071	<.0001
4 - 12	-90.5143	19.7770	340	-4.577	0.0003
5 - 6	-51.1714	19.7770	340	-2.587	0.2595
5 - 7	-102.3714	19.7770	340	-5.176	<.0001
5 - 8	-127.7143	19.7770	340	-6.458	<.0001
5 - 9	-83.2571	19.7770	340	-4.210	0.0016
5 - 10	-33.1714	19.7770	340	-1.677	0.8462
5 - 11	-93.4286	19.7770	340	-4.724	0.0002
5 - 12	-63.8857	19.7770	340	-3.230	0.0516
6 - 7	-51.2000	19.7770	340	-2.589	0.2587
6 - 8	-76.5429	19.7770	340	-3.870	0.0061
6 - 9	-32.0857	19.7770	340	-1.622	0.8719
6 - 10	18.0000	19.7770	340	0.910	0.9980
6 - 11	-42.2571	19.7770	340	-2.137	0.5518
6 - 12	-12.7143	19.7770	340	-0.643	0.9999
7 - 8	-25.3429	19.7770	340	-1.281	0.9714
7 - 9	19.1143	19.7770	340	0.966	0.9967
7 - 10	69.2000	19.7770	340	3.499	0.0223
7 - 11	8.9429	19.7770	340	0.452	1.0000
7 - 12	38.4857	19.7770	340	1.946	0.6863
8 - 9	44.4571	19.7770	340	2.248	0.4725

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Table 3.3 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
8 - 10	94.5429	19.7770	340	4.780	0.0001
8 - 11	34.2857	19.7770	340	1.734	0.8172
8 - 12	63.8286	19.7770	340	3.227	0.0520
9 - 10	50.0857	19.7770	340	2.533	0.2895
9 - 11	-10.1714	19.7770	340	-0.514	1.0000
9 - 12	19.3714	19.7770	340	0.979	0.9964
10 - 11	-60.2571	19.7770	340	-3.047	0.0868
10 - 12	-30.7143	19.7770	340	-1.553	0.9004
11 - 12	29.5429	19.7770	340	1.494	0.9212

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

3.5.2 *Gain*

Below the Trial Analysis on *Gain* for each σ^*.

Table 3.4: *Gain* Trial contrast analysis in tight σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-2.8714	2.9595	340	-0.970	0.9966
2 - 4	-7.0714	2.9595	340	-2.389	0.3765
2 - 5	-1.7571	2.9595	340	-0.594	1.0000
2 - 6	-11.7143	2.9595	340	-3.958	0.0044
2 - 7	-6.1286	2.9595	340	-2.071	0.5990
2 - 8	-9.0286	2.9595	340	-3.051	0.0859
2 - 9	-11.3143	2.9595	340	-3.823	0.0072
2 - 10	-13.4000	2.9595	340	-4.528	0.0004
2 - 11	-10.4857	2.9595	340	-3.543	0.0192
2 - 12	-12.7429	2.9595	340	-4.306	0.0011
3 - 4	-4.2000	2.9595	340	-1.419	0.9430
3 - 5	1.1143	2.9595	340	0.377	1.0000
3 - 6	-8.8429	2.9595	340	-2.988	0.1016

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Table 3.4 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 7	-3.2571	2.9595	340	-1.101	0.9908
3 - 8	-6.1571	2.9595	340	-2.080	0.5921
3 - 9	-8.4429	2.9595	340	-2.853	0.1431
3 - 10	-10.5286	2.9595	340	-3.558	0.0183
3 - 11	-7.6143	2.9595	340	-2.573	0.2673
3 - 12	-9.8714	2.9595	340	-3.336	0.0375
4 - 5	5.3143	2.9595	340	1.796	0.7821
4 - 6	-4.6429	2.9595	340	-1.569	0.8943
4 - 7	0.9429	2.9595	340	0.319	1.0000
4 - 8	-1.9571	2.9595	340	-0.661	0.9999
4 - 9	-4.2429	2.9595	340	-1.434	0.9391
4 - 10	-6.3286	2.9595	340	-2.138	0.5505
4 - 11	-3.4143	2.9595	340	-1.154	0.9867
4 - 12	-5.6714	2.9595	340	-1.916	0.7062
5 - 6	-9.9571	2.9595	340	-3.365	0.0343
5 - 7	-4.3714	2.9595	340	-1.477	0.9265
5 - 8	-7.2714	2.9595	340	-2.457	0.3340
5 - 9	-9.5571	2.9595	340	-3.229	0.0517
5 - 10	-11.6429	2.9595	340	-3.934	0.0048
5 - 11	-8.7286	2.9595	340	-2.949	0.1123
5 - 12	-10.9857	2.9595	340	-3.712	0.0108
6 - 7	5.5857	2.9595	340	1.887	0.7252
6 - 8	2.6857	2.9595	340	0.908	0.9981
6 - 9	0.4000	2.9595	340	0.135	1.0000
6 - 10	-1.6857	2.9595	340	-0.570	1.0000
6 - 11	1.2286	2.9595	340	0.415	1.0000
6 - 12	-1.0286	2.9595	340	-0.348	1.0000
7 - 8	-2.9000	2.9595	340	-0.980	0.9963
7 - 9	-5.1857	2.9595	340	-1.752	0.8069
7 - 10	-7.2714	2.9595	340	-2.457	0.3340
7 - 11	-4.3571	2.9595	340	-1.472	0.9280
7 - 12	-6.6143	2.9595	340	-2.235	0.4816
8 - 9	-2.2857	2.9595	340	-0.772	0.9995
8 - 10	-4.3714	2.9595	340	-1.477	0.9265
8 - 11	-1.4571	2.9595	340	-0.492	1.0000
8 - 12	-3.7143	2.9595	340	-1.255	0.9754
9 - 10	-2.0857	2.9595	340	-0.705	0.9998

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Table 3.4 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
9 - 11	0.8286	2.9595	340	0.280	1.0000
9 - 12	-1.4286	2.9595	340	-0.483	1.0000
10 - 11	2.9143	2.9595	340	0.985	0.9962
10 - 12	0.6571	2.9595	340	0.222	1.0000
11 - 12	-2.2571	2.9595	340	-0.763	0.9996

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 3.5: *Gain* Trial contrast analysis in medium σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-3.7286	3.0790	340	-1.211	0.9810
2 - 4	-5.4429	3.0790	340	-1.768	0.7983
2 - 5	3.9429	3.0790	340	1.281	0.9716
2 - 6	-6.7286	3.0790	340	-2.185	0.5169
2 - 7	-2.1857	3.0790	340	-0.710	0.9998
2 - 8	2.7286	3.0790	340	0.886	0.9984
2 - 9	-15.4429	3.0790	340	-5.016	<.0001
2 - 10	-10.0571	3.0790	340	-3.266	0.0463
2 - 11	-1.9857	3.0790	340	-0.645	0.9999
2 - 12	-1.4143	3.0790	340	-0.459	1.0000
3 - 4	-1.7143	3.0790	340	-0.557	1.0000
3 - 5	7.6714	3.0790	340	2.492	0.3132
3 - 6	-3.0000	3.0790	340	-0.974	0.9965
3 - 7	1.5429	3.0790	340	0.501	1.0000
3 - 8	6.4571	3.0790	340	2.097	0.5802
3 - 9	-11.7143	3.0790	340	-3.805	0.0077
3 - 10	-6.3286	3.0790	340	-2.055	0.6100
3 - 11	1.7429	3.0790	340	0.566	1.0000
3 - 12	2.3143	3.0790	340	0.752	0.9996
4 - 5	9.3857	3.0790	340	3.048	0.0865
4 - 6	-1.2857	3.0790	340	-0.418	1.0000
4 - 7	3.2571	3.0790	340	1.058	0.9932
4 - 8	8.1714	3.0790	340	2.654	0.2258

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Table 3.5 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
4 - 9	-10.0000	3.0790	340	-3.248	0.0490
4 - 10	-4.6143	3.0790	340	-1.499	0.9196
4 - 11	3.4571	3.0790	340	1.123	0.9892
4 - 12	4.0286	3.0790	340	1.308	0.9670
5 - 6	-10.6714	3.0790	340	-3.466	0.0248
5 - 7	-6.1286	3.0790	340	-1.990	0.6558
5 - 8	-1.2143	3.0790	340	-0.394	1.0000
5 - 9	-19.3857	3.0790	340	-6.296	<.0001
5 - 10	-14.0000	3.0790	340	-4.547	0.0004
5 - 11	-5.9286	3.0790	340	-1.925	0.7001
5 - 12	-5.3571	3.0790	340	-1.740	0.8137
6 - 7	4.5429	3.0790	340	1.475	0.9270
6 - 8	9.4571	3.0790	340	3.072	0.0812
6 - 9	-8.7143	3.0790	340	-2.830	0.1512
6 - 10	-3.3286	3.0790	340	-1.081	0.9920
6 - 11	4.7429	3.0790	340	1.540	0.9051
6 - 12	5.3143	3.0790	340	1.726	0.8213
7 - 8	4.9143	3.0790	340	1.596	0.8832
7 - 9	-13.2571	3.0790	340	-4.306	0.0011
7 - 10	-7.8714	3.0790	340	-2.556	0.2762
7 - 11	0.2000	3.0790	340	0.065	1.0000
7 - 12	0.7714	3.0790	340	0.251	1.0000
8 - 9	-18.1714	3.0790	340	-5.902	<.0001
8 - 10	-12.7857	3.0790	340	-4.153	0.0020
8 - 11	-4.7143	3.0790	340	-1.531	0.9085
8 - 12	-4.1429	3.0790	340	-1.346	0.9600
9 - 10	5.3857	3.0790	340	1.749	0.8087
9 - 11	13.4571	3.0790	340	4.371	0.0008
9 - 12	14.0286	3.0790	340	4.556	0.0004
10 - 11	8.0714	3.0790	340	2.621	0.2419
10 - 12	8.6429	3.0790	340	2.807	0.1598
11 - 12	0.5714	3.0790	340	0.186	1.0000

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 11 estimates

Table 3.6: *Gain* Trial contrast analysis in large σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-8.5000	3.1755	340	-2.677	0.2149
2 - 4	8.3286	3.1755	340	2.623	0.2412
2 - 5	11.6000	3.1755	340	3.653	0.0132
2 - 6	7.1714	3.1755	340	2.258	0.4652
2 - 7	8.1857	3.1755	340	2.578	0.2646
2 - 8	-1.3857	3.1755	340	-0.436	1.0000
2 - 9	8.9571	3.1755	340	2.821	0.1547
2 - 10	14.5714	3.1755	340	4.589	0.0003
2 - 11	9.2857	3.1755	340	2.924	0.1198
2 - 12	-4.4143	3.1755	340	-1.390	0.9502
3 - 4	16.8286	3.1755	340	5.300	<.0001
3 - 5	20.1000	3.1755	340	6.330	<.0001
3 - 6	15.6714	3.1755	340	4.935	0.0001
3 - 7	16.6857	3.1755	340	5.255	<.0001
3 - 8	7.1143	3.1755	340	2.240	0.4778
3 - 9	17.4571	3.1755	340	5.497	<.0001
3 - 10	23.0714	3.1755	340	7.265	<.0001
3 - 11	17.7857	3.1755	340	5.601	<.0001
3 - 12	4.0857	3.1755	340	1.287	0.9706
4 - 5	3.2714	3.1755	340	1.030	0.9945
4 - 6	-1.1571	3.1755	340	-0.364	1.0000
4 - 7	-0.1429	3.1755	340	-0.045	1.0000
4 - 8	-9.7143	3.1755	340	-3.059	0.0839
4 - 9	0.6286	3.1755	340	0.198	1.0000
4 - 10	6.2429	3.1755	340	1.966	0.6727
4 - 11	0.9571	3.1755	340	0.301	1.0000
4 - 12	-12.7429	3.1755	340	-4.013	0.0035
5 - 6	-4.4286	3.1755	340	-1.395	0.9491
5 - 7	-3.4143	3.1755	340	-1.075	0.9923
5 - 8	-12.9857	3.1755	340	-4.089	0.0026
5 - 9	-2.6429	3.1755	340	-0.832	0.9991
5 - 10	2.9714	3.1755	340	0.936	0.9975
5 - 11	-2.3143	3.1755	340	-0.729	0.9997
5 - 12	-16.0143	3.1755	340	-5.043	<.0001
6 - 7	1.0143	3.1755	340	0.319	1.0000
6 - 8	-8.5571	3.1755	340	-2.695	0.2066

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Table 3.6 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
6 - 9	1.7857	3.1755	340	0.562	1.0000
6 - 10	7.4000	3.1755	340	2.330	0.4156
6 - 11	2.1143	3.1755	340	0.666	0.9999
6 - 12	-11.5857	3.1755	340	-3.648	0.0134
7 - 8	-9.5714	3.1755	340	-3.014	0.0948
7 - 9	0.7714	3.1755	340	0.243	1.0000
7 - 10	6.3857	3.1755	340	2.011	0.6415
7 - 11	1.1000	3.1755	340	0.346	1.0000
7 - 12	-12.6000	3.1755	340	-3.968	0.0042
8 - 9	10.3429	3.1755	340	3.257	0.0476
8 - 10	15.9571	3.1755	340	5.025	<.0001
8 - 11	10.6714	3.1755	340	3.361	0.0347
8 - 12	-3.0286	3.1755	340	-0.954	0.9971
9 - 10	5.6143	3.1755	340	1.768	0.7981
9 - 11	0.3286	3.1755	340	0.103	1.0000
9 - 12	-13.3714	3.1755	340	-4.211	0.0016
10 - 11	-5.2857	3.1755	340	-1.665	0.8524
10 - 12	-18.9857	3.1755	340	-5.979	<.0001
11 - 12	-13.7000	3.1755	340	-4.314	0.0011

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

3.5.3 *Gain Error*

Below the Trial Analysis on *Gain Error* for each σ^*.

Table 3.7: *Gain Error* Trial contrast analysis in tight σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	5.2000	2.9348	306	1.772	0.7524
3 - 5	4.8857	2.9348	306	1.665	0.8143
3 - 6	-1.6571	2.9348	306	-0.565	0.9999

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Table 3.7 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 7	-8.7429	2.9348	306	-2.979	0.0895
3 - 8	-5.3429	2.9348	306	-1.821	0.7218
3 - 9	-2.5571	2.9348	306	-0.871	0.9972
3 - 10	-1.4714	2.9348	306	-0.501	1.0000
3 - 11	-3.8857	2.9348	306	-1.324	0.9475
3 - 12	-2.6286	2.9348	306	-0.896	0.9965
4 - 5	-0.3143	2.9348	306	-0.107	1.0000
4 - 6	-6.8571	2.9348	306	-2.336	0.3686
4 - 7	-13.9429	2.9348	306	-4.751	0.0001
4 - 8	-10.5429	2.9348	306	-3.592	0.0138
4 - 9	-7.7571	2.9348	306	-2.643	0.2024
4 - 10	-6.6714	2.9348	306	-2.273	0.4096
4 - 11	-9.0857	2.9348	306	-3.096	0.0650
4 - 12	-7.8286	2.9348	306	-2.667	0.1918
5 - 6	-6.5429	2.9348	306	-2.229	0.4390
5 - 7	-13.6286	2.9348	306	-4.644	0.0002
5 - 8	-10.2286	2.9348	306	-3.485	0.0198
5 - 9	-7.4429	2.9348	306	-2.536	0.2537
5 - 10	-6.3571	2.9348	306	-2.166	0.4825
5 - 11	-8.7714	2.9348	306	-2.989	0.0872
5 - 12	-7.5143	2.9348	306	-2.560	0.2413
6 - 7	-7.0857	2.9348	306	-2.414	0.3209
6 - 8	-3.6857	2.9348	306	-1.256	0.9623
6 - 9	-0.9000	2.9348	306	-0.307	1.0000
6 - 10	0.1857	2.9348	306	0.063	1.0000
6 - 11	-2.2286	2.9348	306	-0.759	0.9990
6 - 12	-0.9714	2.9348	306	-0.331	1.0000
7 - 8	3.4000	2.9348	306	1.159	0.9778
7 - 9	6.1857	2.9348	306	2.108	0.5235
7 - 10	7.2714	2.9348	306	2.478	0.2848
7 - 11	4.8571	2.9348	306	1.655	0.8195
7 - 12	6.1143	2.9348	306	2.083	0.5407
8 - 9	2.7857	2.9348	306	0.949	0.9946
8 - 10	3.8714	2.9348	306	1.319	0.9487
8 - 11	1.4571	2.9348	306	0.497	1.0000
8 - 12	2.7143	2.9348	306	0.925	0.9956
9 - 10	1.0857	2.9348	306	0.370	1.0000

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Table 3.7 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
9 - 11	-1.3286	2.9348	306	-0.453	1.0000
9 - 12	-0.0714	2.9348	306	-0.024	1.0000
10 - 11	-2.4143	2.9348	306	-0.823	0.9982
10 - 12	-1.1571	2.9348	306	-0.394	1.0000
11 - 12	1.2571	2.9348	306	0.428	1.0000

Note: contrasts are still on the (scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 3.8: *Gain Error* Trial contrast analysis in medium σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	-14.7857	3.0293	306	-4.881	0.0001
3 - 5	-2.1714	3.0293	306	-0.717	0.9994
3 - 6	-5.0000	3.0293	306	-1.651	0.8219
3 - 7	-7.5429	3.0293	306	-2.490	0.2780
3 - 8	-12.9571	3.0293	306	-4.277	0.0010
3 - 9	5.7143	3.0293	306	1.886	0.6784
3 - 10	-0.1714	3.0293	306	-0.057	1.0000
3 - 11	-8.7429	3.0293	306	-2.886	0.1140
3 - 12	-8.8143	3.0293	306	-2.910	0.1073
4 - 5	12.6143	3.0293	306	4.164	0.0016
4 - 6	9.7857	3.0293	306	3.230	0.0440
4 - 7	7.2429	3.0293	306	2.391	0.3349
4 - 8	1.8286	3.0293	306	0.604	0.9999
4 - 9	20.5000	3.0293	306	6.767	<.0001
4 - 10	14.6143	3.0293	306	4.824	0.0001
4 - 11	6.0429	3.0293	306	1.995	0.6034
4 - 12	5.9714	3.0293	306	1.971	0.6199
5 - 6	-2.8286	3.0293	306	-0.934	0.9952
5 - 7	-5.3714	3.0293	306	-1.773	0.7516
5 - 8	-10.7857	3.0293	306	-3.560	0.0154
5 - 9	7.8857	3.0293	306	2.603	0.2207
5 - 10	2.0000	3.0293	306	0.660	0.9997
5 - 11	-6.5714	3.0293	306	-2.169	0.4803

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Table 3.8 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
5 - 12	-6.6429	3.0293	306	-2.193	0.4640
6 - 7	-2.5429	3.0293	306	-0.839	0.9979
6 - 8	-7.9571	3.0293	306	-2.627	0.2098
6 - 9	10.7143	3.0293	306	3.537	0.0167
6 - 10	4.8286	3.0293	306	1.594	0.8503
6 - 11	-3.7429	3.0293	306	-1.236	0.9661
6 - 12	-3.8143	3.0293	306	-1.259	0.9617
7 - 8	-5.4143	3.0293	306	-1.787	0.7428
7 - 9	13.2571	3.0293	306	4.376	0.0007
7 - 10	7.3714	3.0293	306	2.433	0.3098
7 - 11	-1.2000	3.0293	306	-0.396	1.0000
7 - 12	-1.2714	3.0293	306	-0.420	1.0000
8 - 9	18.6714	3.0293	306	6.164	<.0001
8 - 10	12.7857	3.0293	306	4.221	0.0013
8 - 11	4.2143	3.0293	306	1.391	0.9293
8 - 12	4.1429	3.0293	306	1.368	0.9361
9 - 10	-5.8857	3.0293	306	-1.943	0.6396
9 - 11	-14.4571	3.0293	306	-4.772	0.0001
9 - 12	-14.5286	3.0293	306	-4.796	0.0001
10 - 11	-8.5714	3.0293	306	-2.830	0.1313
10 - 12	-8.6429	3.0293	306	-2.853	0.1238
11 - 12	-0.0714	3.0293	306	-0.024	1.0000

Note: contrasts are still on the (scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 3.9: *Gain Error* Trial contrast analysis in large σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	-11.8286	2.9947	306	-3.950	0.0038
3 - 5	-8.6000	2.9947	306	-2.872	0.1182
3 - 6	-0.1714	2.9947	306	-0.057	1.0000
3 - 7	-1.6857	2.9947	306	-0.563	0.9999
3 - 8	-6.1143	2.9947	306	-2.042	0.5702
3 - 9	-16.9571	2.9947	306	-5.662	<.0001

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Table 3.9 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 10	-22.5714	2.9947	306	-7.537	<.0001
3 - 11	-16.2857	2.9947	306	-5.438	<.0001
3 - 12	-3.0857	2.9947	306	-1.030	0.9902
4 - 5	3.2286	2.9947	306	1.078	0.9865
4 - 6	11.6571	2.9947	306	3.893	0.0047
4 - 7	10.1429	2.9947	306	3.387	0.0272
4 - 8	5.7143	2.9947	306	1.908	0.6636
4 - 9	-5.1286	2.9947	306	-1.713	0.7877
4 - 10	-10.7429	2.9947	306	-3.587	0.0140
4 - 11	-4.4571	2.9947	306	-1.488	0.8960
4 - 12	8.7429	2.9947	306	2.919	0.1047
5 - 6	8.4286	2.9947	306	2.815	0.1362
5 - 7	6.9143	2.9947	306	2.309	0.3863
5 - 8	2.4857	2.9947	306	0.830	0.9981
5 - 9	-8.3571	2.9947	306	-2.791	0.1443
5 - 10	-13.9714	2.9947	306	-4.665	0.0002
5 - 11	-7.6857	2.9947	306	-2.566	0.2383
5 - 12	5.5143	2.9947	306	1.841	0.7082
6 - 7	-1.5143	2.9947	306	-0.506	1.0000
6 - 8	-5.9429	2.9947	306	-1.984	0.6106
6 - 9	-16.7857	2.9947	306	-5.605	<.0001
6 - 10	-22.4000	2.9947	306	-7.480	<.0001
6 - 11	-16.1143	2.9947	306	-5.381	<.0001
6 - 12	-2.9143	2.9947	306	-0.973	0.9935
7 - 8	-4.4286	2.9947	306	-1.479	0.8997
7 - 9	-15.2714	2.9947	306	-5.100	<.0001
7 - 10	-20.8857	2.9947	306	-6.974	<.0001
7 - 11	-14.6000	2.9947	306	-4.875	0.0001
7 - 12	-1.4000	2.9947	306	-0.467	1.0000
8 - 9	-10.8429	2.9947	306	-3.621	0.0125
8 - 10	-16.4571	2.9947	306	-5.495	<.0001
8 - 11	-10.1714	2.9947	306	-3.396	0.0264
8 - 12	3.0286	2.9947	306	1.011	0.9914
9 - 10	-5.6143	2.9947	306	-1.875	0.6861
9 - 11	0.6714	2.9947	306	0.224	1.0000
9 - 12	13.8714	2.9947	306	4.632	0.0002
10 - 11	6.2857	2.9947	306	2.099	0.5297

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Table 3.9 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
10 - 12	19.4857	2.9947	306	6.507	<.0001
11 - 12	13.2000	2.9947	306	4.408	0.0006

Note: contrasts are still on the (scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

3.5.4 *SD - Error*

Below the Trial Analysis on *SD - Error* for each σ^*.

Table 3.10: *SD-Error* Trial contrast analysis in tight σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	47.0429	10.6304	306	4.425	0.0006
3 - 5	101.3571	10.6304	306	9.535	<.0001
3 - 6	157.4143	10.6304	306	14.808	<.0001
3 - 7	121.5286	10.6304	306	11.432	<.0001
3 - 8	128.7857	10.6304	306	12.115	<.0001
3 - 9	134.0429	10.6304	306	12.609	<.0001
3 - 10	130.7143	10.6304	306	12.296	<.0001
3 - 11	144.2286	10.6304	306	13.568	<.0001
3 - 12	130.6000	10.6304	306	12.286	<.0001
4 - 5	54.3143	10.6304	306	5.109	<.0001
4 - 6	110.3714	10.6304	306	10.383	<.0001
4 - 7	74.4857	10.6304	306	7.007	<.0001
4 - 8	81.7429	10.6304	306	7.690	<.0001
4 - 9	87.0000	10.6304	306	8.184	<.0001
4 - 10	83.6714	10.6304	306	7.871	<.0001
4 - 11	97.1857	10.6304	306	9.142	<.0001
4 - 12	83.5571	10.6304	306	7.860	<.0001
5 - 6	56.0571	10.6304	306	5.273	<.0001
5 - 7	20.1714	10.6304	306	1.898	0.6708
5 - 8	27.4286	10.6304	306	2.580	0.2316

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Table 3.10 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
5 - 9	32.6857	10.6304	306	3.075	0.0690
5 - 10	29.3571	10.6304	306	2.762	0.1546
5 - 11	42.8714	10.6304	306	4.033	0.0028
5 - 12	29.2429	10.6304	306	2.751	0.1586
6 - 7	-35.8857	10.6304	306	-3.376	0.0281
6 - 8	-28.6286	10.6304	306	-2.693	0.1811
6 - 9	-23.3714	10.6304	306	-2.199	0.4600
6 - 10	-26.7000	10.6304	306	-2.512	0.2664
6 - 11	-13.1857	10.6304	306	-1.240	0.9652
6 - 12	-26.8143	10.6304	306	-2.522	0.2607
7 - 8	7.2571	10.6304	306	0.683	0.9996
7 - 9	12.5143	10.6304	306	1.177	0.9753
7 - 10	9.1857	10.6304	306	0.864	0.9974
7 - 11	22.7000	10.6304	306	2.135	0.5040
7 - 12	9.0714	10.6304	306	0.853	0.9976
8 - 9	5.2571	10.6304	306	0.495	1.0000
8 - 10	1.9286	10.6304	306	0.181	1.0000
8 - 11	15.4429	10.6304	306	1.453	0.9092
8 - 12	1.8143	10.6304	306	0.171	1.0000
9 - 10	-3.3286	10.6304	306	-0.313	1.0000
9 - 11	10.1857	10.6304	306	0.958	0.9942
9 - 12	-3.4429	10.6304	306	-0.324	1.0000
10 - 11	13.5143	10.6304	306	1.271	0.9593
10 - 12	-0.1143	10.6304	306	-0.011	1.0000
11 - 12	-13.6286	10.6304	306	-1.282	0.9570

Note: contrasts are still on the (scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 3.11: *SD-Error* Trial contrast analysis in medium σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	45.2857	10.8248	306	4.184	0.0015
3 - 5	80.9857	10.8248	306	7.482	<.0001
3 - 6	145.0286	10.8248	306	13.398	<.0001

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Table 3.11 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 7	174.0429	10.8248	306	16.078	<.0001
3 - 8	165.7429	10.8248	306	15.311	<.0001
3 - 9	154.7857	10.8248	306	14.299	<.0001
3 - 10	147.8714	10.8248	306	13.660	<.0001
3 - 11	143.7857	10.8248	306	13.283	<.0001
3 - 12	155.3286	10.8248	306	14.349	<.0001
4 - 5	35.7000	10.8248	306	3.298	0.0359
4 - 6	99.7429	10.8248	306	9.214	<.0001
4 - 7	128.7571	10.8248	306	11.895	<.0001
4 - 8	120.4571	10.8248	306	11.128	<.0001
4 - 9	109.5000	10.8248	306	10.116	<.0001
4 - 10	102.5857	10.8248	306	9.477	<.0001
4 - 11	98.5000	10.8248	306	9.100	<.0001
4 - 12	110.0429	10.8248	306	10.166	<.0001
5 - 6	64.0429	10.8248	306	5.916	<.0001
5 - 7	93.0571	10.8248	306	8.597	<.0001
5 - 8	84.7571	10.8248	306	7.830	<.0001
5 - 9	73.8000	10.8248	306	6.818	<.0001
5 - 10	66.8857	10.8248	306	6.179	<.0001
5 - 11	62.8000	10.8248	306	5.802	<.0001
5 - 12	74.3429	10.8248	306	6.868	<.0001
6 - 7	29.0143	10.8248	306	2.680	0.1864
6 - 8	20.7143	10.8248	306	1.914	0.6598
6 - 9	9.7571	10.8248	306	0.901	0.9964
6 - 10	2.8429	10.8248	306	0.263	1.0000
6 - 11	-1.2429	10.8248	306	-0.115	1.0000
6 - 12	10.3000	10.8248	306	0.952	0.9945
7 - 8	-8.3000	10.8248	306	-0.767	0.9990
7 - 9	-19.2571	10.8248	306	-1.779	0.7480
7 - 10	-26.1714	10.8248	306	-2.418	0.3190
7 - 11	-30.2571	10.8248	306	-2.795	0.1427
7 - 12	-18.7143	10.8248	306	-1.729	0.7783
8 - 9	-10.9571	10.8248	306	-1.012	0.9914
8 - 10	-17.8714	10.8248	306	-1.651	0.8216
8 - 11	-21.9571	10.8248	306	-2.028	0.5796
8 - 12	-10.4143	10.8248	306	-0.962	0.9941
9 - 10	-6.9143	10.8248	306	-0.639	0.9998

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Table 3.11 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
9 - 11	-11.0000	10.8248	306	-1.016	0.9911
9 - 12	0.5429	10.8248	306	0.050	1.0000
10 - 11	-4.0857	10.8248	306	-0.377	1.0000
10 - 12	7.4571	10.8248	306	0.689	0.9996
11 - 12	11.5429	10.8248	306	1.066	0.9875

Note: contrasts are still on the (scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 3.12: *SD-Error* Trial contrast analysis in large σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	49.3286	10.5427	306	4.679	0.0002
3 - 5	137.2857	10.5427	306	13.022	<.0001
3 - 6	156.3857	10.5427	306	14.834	<.0001
3 - 7	188.2714	10.5427	306	17.858	<.0001
3 - 8	195.2571	10.5427	306	18.521	<.0001
3 - 9	179.4143	10.5427	306	17.018	<.0001
3 - 10	181.5857	10.5427	306	17.224	<.0001
3 - 11	183.8286	10.5427	306	17.437	<.0001
3 - 12	184.5000	10.5427	306	17.500	<.0001
4 - 5	87.9571	10.5427	306	8.343	<.0001
4 - 6	107.0571	10.5427	306	10.155	<.0001
4 - 7	138.9429	10.5427	306	13.179	<.0001
4 - 8	145.9286	10.5427	306	13.842	<.0001
4 - 9	130.0857	10.5427	306	12.339	<.0001
4 - 10	132.2571	10.5427	306	12.545	<.0001
4 - 11	134.5000	10.5427	306	12.758	<.0001
4 - 12	135.1714	10.5427	306	12.821	<.0001
5 - 6	19.1000	10.5427	306	1.812	0.7274
5 - 7	50.9857	10.5427	306	4.836	0.0001
5 - 8	57.9714	10.5427	306	5.499	<.0001
5 - 9	42.1286	10.5427	306	3.996	0.0032
5 - 10	44.3000	10.5427	306	4.202	0.0014
5 - 11	46.5429	10.5427	306	4.415	0.0006

Continued on next page

Table 3.12 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
5 - 12	47.2143	10.5427	306	4.478	0.0004
6 - 7	31.8857	10.5427	306	3.024	0.0792
6 - 8	38.8714	10.5427	306	3.687	0.0099
6 - 9	23.0286	10.5427	306	2.184	0.4699
6 - 10	25.2000	10.5427	306	2.390	0.3353
6 - 11	27.4429	10.5427	306	2.603	0.2207
6 - 12	28.1143	10.5427	306	2.667	0.1922
7 - 8	6.9857	10.5427	306	0.663	0.9997
7 - 9	-8.8571	10.5427	306	-0.840	0.9979
7 - 10	-6.6857	10.5427	306	-0.634	0.9998
7 - 11	-4.4429	10.5427	306	-0.421	1.0000
7 - 12	-3.7714	10.5427	306	-0.358	1.0000
8 - 9	-15.8429	10.5427	306	-1.503	0.8904
8 - 10	-13.6714	10.5427	306	-1.297	0.9538
8 - 11	-11.4286	10.5427	306	-1.084	0.9860
8 - 12	-10.7571	10.5427	306	-1.020	0.9909
9 - 10	2.1714	10.5427	306	0.206	1.0000
9 - 11	4.4143	10.5427	306	0.419	1.0000
9 - 12	5.0857	10.5427	306	0.482	1.0000
10 - 11	2.2429	10.5427	306	0.213	1.0000
10 - 12	2.9143	10.5427	306	0.276	1.0000
11 - 12	0.6714	10.5427	306	0.064	1.0000

Note: contrasts are still on the (scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 10 estimates

CHAPTER 4

General Decision - Making Ability of Élite Open- and Closed-Skill Sport Athletes - Study 3

4.1 Introduction

Everyday, people have to make decisions under time pressure and/or under a competitive set. Examples are many professionals such as medical, military, law enforcement, firefighting as well as sports athletes (Causer et al., 2013; Rainieri et al., 2020b,a; Williams and Elliott, 1999). They have to understand the environment as quickly as possible, weigh the possible consequences, and put in action the best decision for that particular situation (Bang and Fleming, 2018; Raab, 2007). This happens very often under time pressure or in very high stressful sets.

It is well established that emotional states can affect performance, and they can act as scale needles to complete the task satisfactorily or incorrectly (Bang and Fleming, 2018; Yeung and Summerfield, 2012). One of the most emotional states investigated is anxiety due also to their important role in our society. Anxiety can be divided into two components: somatic and cognitive anxiety. The somatic anxiety is given to the increase of psychological parameters such as the heart rate, sweating, the presence of the butterfly in the stomach, and the general tension of muscles; cognitive anxiety instead refers to the presence of worrisome thoughts that could lead to a shift of attentional processes.

According to the Proficiency Efficiency Theory (PET, Eysenck and Calvo 1992), worrisome thoughts can affect the performance more than somatic anxiety, influencing the participants' behaviour. In particular, according to the Attentional Control Theory (ACT, Eysenck et al. 2007), when we are in stressful conditions, an impairment of the central cognitive function, such as working memory and attention, occurs. The anxiety disrupts the balance of the two attentional systems identified by Corbetta and Shulman (2002). One is referred to as the driven top-down system that the individual's achievement and expectations influence it. In contrast, the other one is referred to as the stimulus-driven system in which the salience of the stimuli influences the attention. Thus, the impairment in attentional processes, for instance, leads to a shift of attention to irrelevant/threatening stimuli that could be endogenous (e.g., worrisome thoughts) or exogenous (e.g., irrelevant information in the task). This can bring to a decrease in general efficiency.

In general, it is well accepted that anxiety states can reduce performance, but if some strategies can be deployed, the performance's decline could be stopped. In particular, in accordance with the assumption of the *PET* (Eysenck and Calvo, 1992), if people are able to increase their motivation and their cognitive effort on the task, they should be able to avoid the negative effect of anxiety and maintain stable or increase performance.

These two theories and the new extension (Eysenck and Calvo, 1992; Eysenck et al., 2007; Derakshan and Eysenck, 2009) analysed how anxiety can affect performance. However, as suggested by the authors, further investigation in supporting these theories is necessary due to the difficulty of completely understanding the phenomena. The results of many investigations are still controversial.

In order to test anxiety and pressure effects on general decision-making ability, we focused our attention on athletes. Indeed, athletes must compete in very stressful conditions, and they should be aware of these feelings and, consequently, gain benefits from them (Robazza and Bortoli, 2003).

We can think about the Champions League Final that is the most important international football competition. Finalist teams compete for about 9 months to reach the final, and in this match, they could through away all efforts made during the sports year. Thus, each football player should be o9able to manage the pressure and make the most appropriate decisions to reach the aim.

It is known expert/èlite athletes have superior perceptual-cognitive skills than their counterparts less expert and lay-people. This is particularly true for specific perceptual-cognitive skills (Mann et al., 2007; Russo and Ottoboni, 2019). Moreover, recent investigations have been focused their attention on general perceptual-cognitive function. They have been summarised in some systematic reviews and meta-analyses (Voss et al., 2010; Memmert et al., 2009; Russo and Ottoboni, 2019; Scharfen and Memmert, 2019). Specifically, even if some results are quite inconsistent, most of the investigations highlighted a positive relation between general cognitive function and sports practice. Additionally, in the last years, researchers have focused their attention on the possible differences between athletes of different sports. Indeed, we can divide sports into two categories: open-skill and closed-skill sports. As previously reported in Chapter 1 and Chapter 3. Open-skill sports are characterised by unstable environments where athletes have to adapt their actions to mutable situations. Closed skill sports instead are characterised by quite stable environments.

Even in this case, several investigations analysed the general cognitive function of open- Skill and Closed Skill sports athletes. A recent systematic review (Gu et al., 2019) highlighted that people who perform open-skill activities have better general cognitive function than those used to practice closed-skill activities. However, researchers have focused their attention on basic cognitive function, while high-order cognitive functions such as decision-making are less investigated.

Actually, a study investigated the general decision-making ability in football (Gonzaga et al., 2014). Authors investigate decision processes through IOWA Gambling Task (Bechara et al., 1997). They highlighted that forward players were willing to risk more than defensive players and defensive players were less impulsive than forwarding players.

In the present research, we investigated the statistical decision-making of open- and Closed Skill athletes. To the best of our knowledge, decision processes in uncertain environments have not been investigated in this kind of participant. In particular, with this experiment, we would like to understand whether there were differences in the statistical decision processes between èlite athletes of open- and Closed Skill sports. Moreover, the present research analysed another aspect that was how both groups manage stressful situations. Additionally, data collected from athletes were compared to a group of students of the University of Bologna.

Given the nature of open-skill sports in which the uncertainty is much higher than in closed skill sports, we hypothesised that open-skill sports athletes should perform better in the statistical decision task than closed-skill sports athletes. However, we expected better performance for closed-skill athletes compared to the control group. To be precise, we expected in open-skill athletes better *SE* (Equation 1.1, ref. 1.3.1.2), *Gain* (ref. 1.3.1.2) and *Gain Error* (Equation 1.2, ref. 1.3.1.2) compared to closed-skill sport athletes and control group. No differences, instead, were hypothesised in *SD-E* (Equation 1.3, 1.3.1.2) and σ_U^* (ref. 1.3.1.2). This experiment also examined some assumptions of the *PET* and *ACT* (Eysenck and Calvo, 1992; Eysenck et al., 2007).

In particular, we tested whether the participants are able to increase performance when they were exposed to psychological pressure. This should be due to the increment of the mental effort in the task. Again, we hypothesised an impairment of the central function was expected to shift the participants' visual attention to the task's irrelevant and/or threatening stimuli. Specifically, we supposed that when participants were exposed to psychological pressure in our task, they should shift their attention to exogenous irrelevant/threatening stimuli presented in the task, such as the countdown, the value of the bet, and the points gained (see Fig 4.5). Data from athletes and the control group were controlled with fluid intelligence ability (Raven and Court 1998, see Fig. 1.3, ref. 1.3.2.1).

4.2 Methods

4.2.1 Participants

Twenty-four èlite football and basketball players (M_{age} = 18.0, SD_{age} = 1.0 years old) constituted the open-skill group (OSG), while 13 èlite Athletics athletes and swimmers (M_{age} = 21.4, SD_{age} = 3.4 years old) formed the closed-skill group (CSG). Control group (CG) was formed by 36 participants ($M_{age} = 23.6$, $SD_{age} = 1.6$ years old).

Football and basket players were recruited from the "Primavera" team of Bologna F.C. and from U18 and U19 of Fortitudo Basket Bologna. Closed-skill athletes were recruited from A.S.D. Fratellanza.

Participants were also divided according to their Raven score in Raven A group, those who performed above the median and in Raven B, those who performed below or equal to the sample's median. The median of the entire sample was 19 correct responses.

To control whether the sports groups were not different in Raven score, a linear regression analysis was performed. The analysis revealed that Raven score was not influenced by the Type of Sport group ($F(2,70) = 2.16$, $p > .05$). The bio-ethics committee of the University of Bologna has approved the study (Fig. A.1) and participants filled the informed consent (Fig. A.3).

4.2.2 Procedure

Before starting the experiment, participants filled the informed consent. To test the effect of pressure, all participants performed the perceptual decision task two times. One in standard condition and one under pressure condition. Before each trial, the STAIS (state anxiety) questionnaire (Spielberger, 1983) was filled. In order to avoid learning effects, the two conditions were counterbalanced (e.g., A-B and B-A).

In Low-Pressure Session (LPS), participants were told to do the best they could. In High-Pressure Session (HPS), participants were told that the performance would be compared to the other University-mates, teammates or training-mates, and standing would be created.

They filled the State Anxiety Questionnaire (Spielberger, 1983) before starting the decision task in LPS and HPS.

Eye-movements were recorded in both the trials and for each participant. All participants had corrected with contact lenses or normal vision, and before starting the experiment, each participant performed the nine points system eye-tracking calibration.

Participants were seated at a distance of about 800 mm from the screen. OSG and CG participants wore a Heart Rate (HR) monitor for the entire experimental session to measure the somatic pressure. Due to the COVID-19 pandemic, to reduce the time of the experiment session and avoid contact with participants, HR of CSG was not monitored and recorded.

Raven-APM (ref. 1.3.2.1, Raven and Court 1998), 20 minutes version was performed after the two trials of the perceptual decision task (Hamel and Schmittmann, 2006).

4.2.3 Data analysis

Data analysis was performed through R Software (R Core Team, 2013) with RStudio (RStudio Team, 2015). The mental effort was analysed through a linear mixed-effect in which the dependent variable was RSME score, and the independent variables were: Type of Sport (3 levels: OSG, CSG and CG); Experimental Session (2 levels: LPS and HPS); and Intelligence (2 levels: Raven A and Raven B).

A similar analysis was performed to analyse State Anxiety (Spielberger, 1983), Heart Rate (HR) and Eye-movements. Specifically, in the latter analysis, the dependent variables were the Number of Fixations and Fixation Duration (FD). Independent variables were: Type of Sport (3 levels), Experimental Session (2 levels: HPS and LPS) and Fixation Location (2 levels: Top of the screen (Top) and Circle, Fig. 4.5). In order to reduce non-normality, RSME score, STAIS and HR were ranks transformed.

To analyse the Number of Fixations and Fixation Duration, we modified the *EyeMMV toolbox* (Krassanakis et al., 2014). The minimum fixation duration was set at 150 ms. Eye-tracker had a sampling frequency of about 90 Hz; however, we performed an interpolation to reduce the sampling frequency to 60 Hz to have a stable sample frequency. This sampling frequency should be enough to analyse the number of fixations and fixation duration (Stuart et al., 2019).

In statistical decision task for each parameter (Sub-chapter 1.3.1.2; *Spatial Error* (SE, Eq. 1.1), *Gain*, *Gain Error* (Eq. 1.2, Standard Deviation Error ($SD-E$, Eq. 1.3) and *Bucket length* (σ^U), we performed a linear mixed-effect regression model (Bates et al., 2015). Independent variables were Type of Sport (3 levels: OSG, CSG and CG), Condition (3 levels: Tight σ^*, Medium σ^* and Large σ^*), Experimental Session (2 levels, HPS and LPS), Session (Learning effect , 2 levels: First and Second Session) and

Trial (10 or 11 levels), that was the time fixed effect. For each parameter, a step-wise regression - backwards with *the lme4 package* (Bates et al., 2015) was performed.

As performed in study 1 (Chapter 2 and Chapter 3) data recorded from the task was analysed in the following way: for the *Spatial Error* and *Gain* parameters, the first trial after the beginning of a new condition of dots throw was removed from the analysis as well as the trial after the $12^t h$ (i.e., 11 trials for each participant were analysed). In *Gain Error* and *SD-E*, even the second trial was removed from the analysis because both humans and OUM (1.3.1.3) were not able to estimate the standard deviation of throw directions. In order to reduce non-normality and heteroskedasticity, *Spatial Error*, *Gain*, *SD-E*, and σ^U were rank transformed.

4.3 Results

4.3.1 Pressure induction

4.3.1.1 State Anxiety

Analysis on anxiety revealed that neither single factors nor interactions were significant ($F(1,69) < 1.87$, $p > .05$; Fig. 4.1).

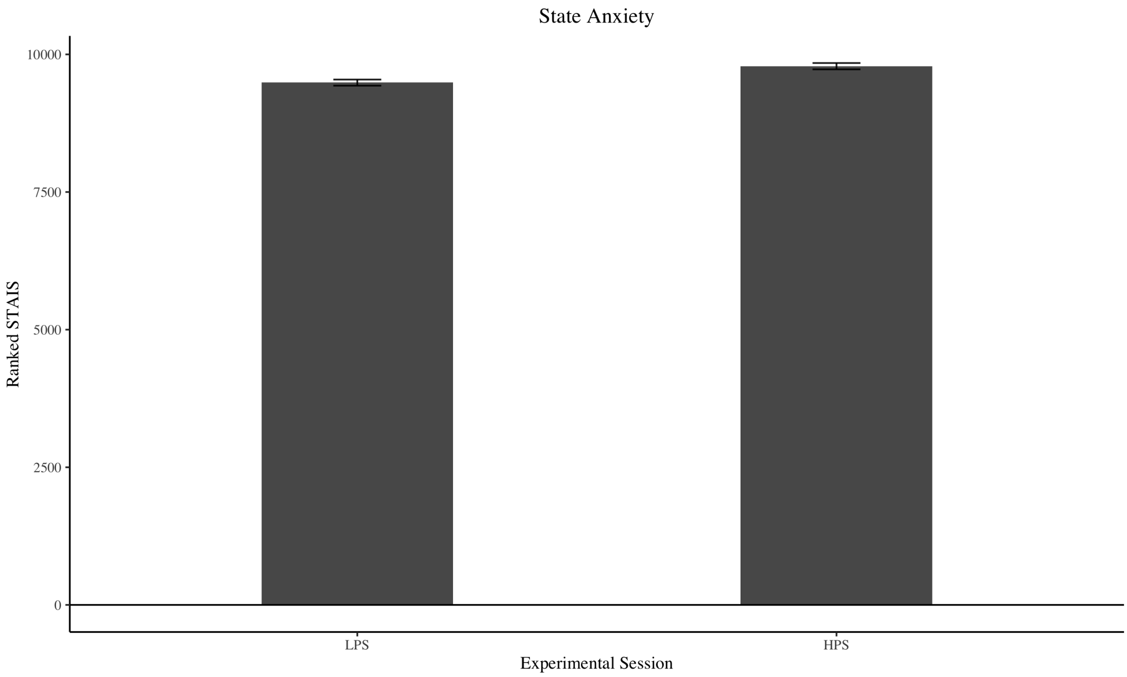

Figure 4.1: State Anxiety in LPS and HPS. The chart reports *Ranked State Anxiety Score* average and SEM for each Experimental Session.

4.3.1.2 Hear Rate (HR)

As reported in Sub-chapter 1.2, due to COVID-19, we were not able to record the heart rate in athletic athletes. Actually, four CSG athletes performed the task before the COVID-19 pandemic. However, their HR data was removed from the analysis. In total, the HR of 66 participants was monitored (24 OSG and 36 CG). Step-wise regression analysis on HR as dependent variable revealed single factor Experimental Session and single factor Type of Sport were significant ($F(1,55) = 11.91$, $p = .001$; $F(1,54) = 8.11$, $p = .006$, respectively). In particular, HR was higher in HPS compared to LPS (Fig. 4.2) and HR was higher in OSG compared to CG.

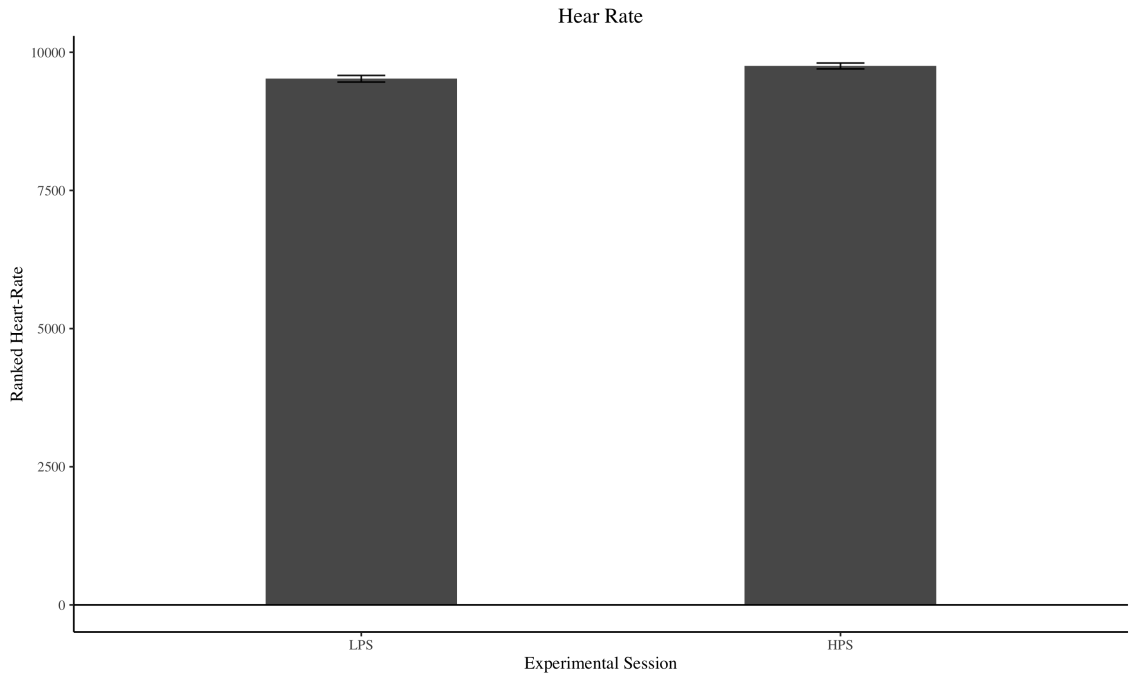

Figure 4.2: HR in the two experimental sessions. The chart reports *the Ranked HR* average and SEM for LPS and HPS.

4.3.1.3 Rating Scale Mental Effort (RSME)

Step-wise regressions on Rating Scale Mental Effort analysis revealed higher mental effort HPS compared to LPS ($F(1,71) = 22.26$, $p < .0001$, Fig. 4.3). Single factor intelligence was not significant ($F(1,71) = 0.64$, $p > .05$), but its interaction with Experimental Session was significant ($F(1,71) = 4.28$, $p = .04$). Post-hoc analysis revealed no-differences between Raven A and Raven participants in both HPS and LPS ($t(82.99) < 1.35$, $p > .05$). However, the analysis highlighted and Raven B participants had higher RSME in HPS compared to LPS ($t(71) = 4.90$, $p < .0001$), while Raven A participants did not show differences between the two experimental sessions ($t(71) = 1.84$, $p = .3$, see Fig. 4.4).

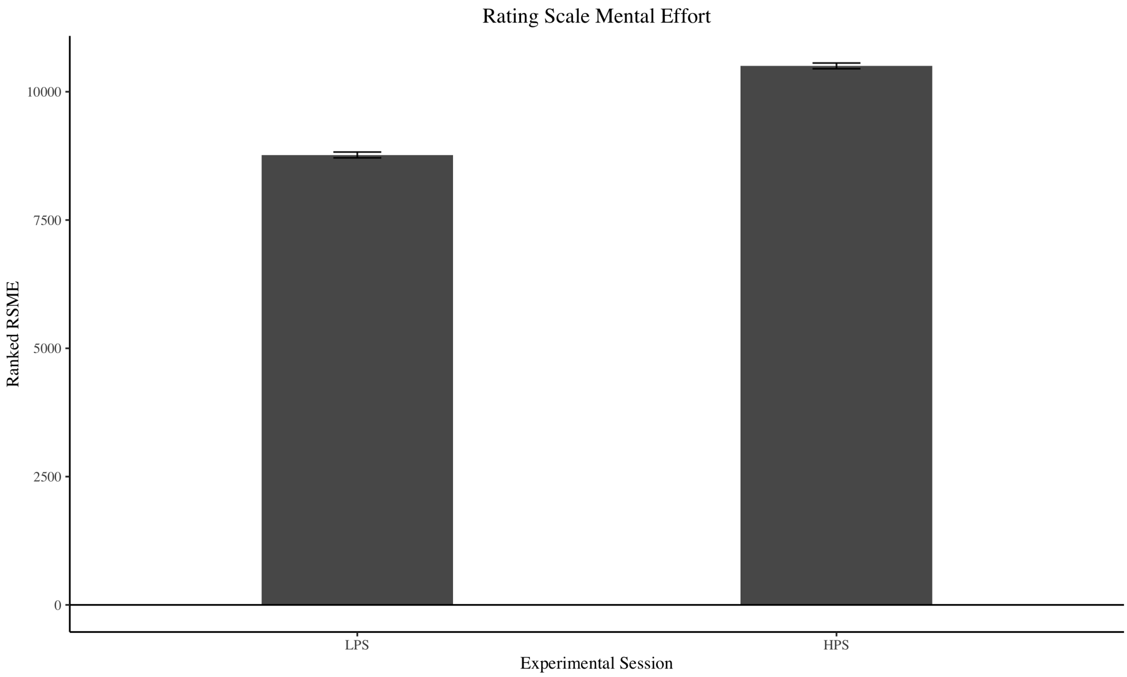

Figure 4.3: RSME in LPS and HPS. The chart reports*Ranked RSME* average and SEM for each Experimental Session are reported.

4.3.1.4 Eye-Movements

Due to some problems in eye-tracker configuration, we were not able to analyse the eye movements of 3 participants, while in one participant, we recorded only the Low Pressure Session.

Number of Fixation

Step-wise regression on the linear mixed-effects model on Number of Fixation revealed that only single factor Fixation Location was significant ($F(1,464.38) = 880.24$, $p < .0001$). Specifically, participants made more fixation on Circle compared to on Top.

Fixation Duration Step-wise regression highlighted only single factor Fixation Location was significant ($F(1,463.55) = 316.5$, $p < .0001$). In

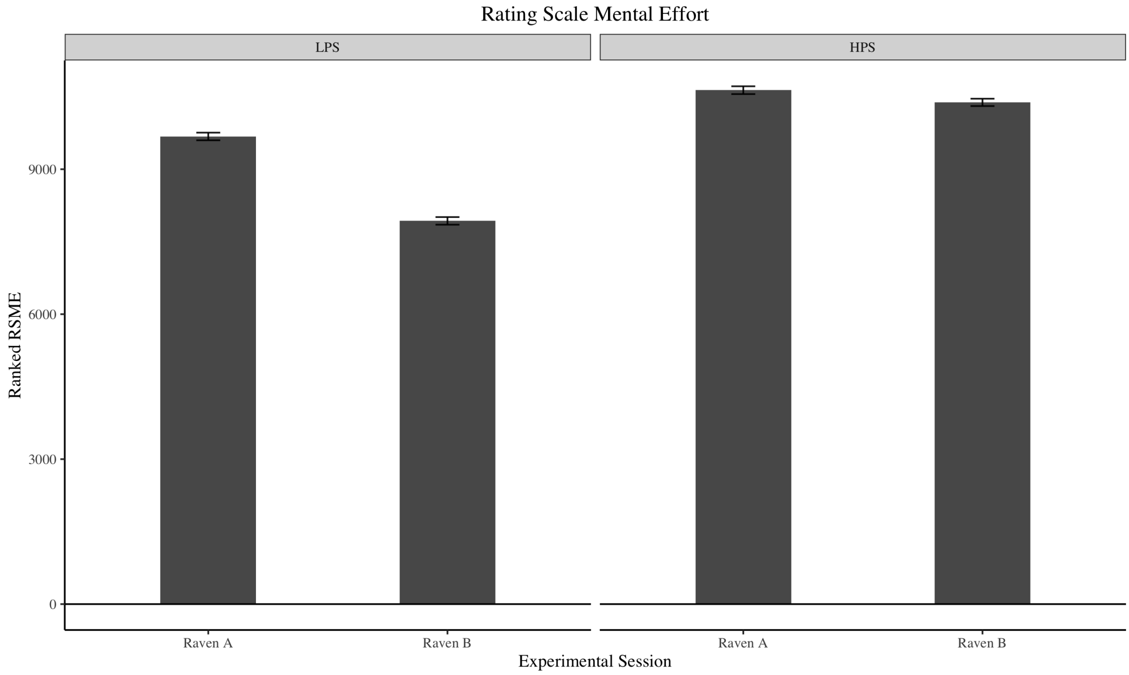

Figure 4.4: RSME in LPS and HPS for Raven A and Raven B participants. The chart reports *Ranked RSME* average and SEM

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particular, the fixations on Circle were longer compared to fixations made on Top.

4.3.2 Statistical Decision Task

4.3.2.1 Spatial Error

The step-wise regression removed the non-significant fixed effects. Final linear mixed-effect model highlighted the single factor Condition was significant ($F(2,4721) = 6.82$, $p = .001$). Post-hoc analysis revealed better *SE* in Tight σ^* compared to Medium and Large σ^* ($t(4721)13.96$, $p < .0001$; $t(4721) = 30.01$, $p < .0001$, respectively). Moreover, *SE* was bet-

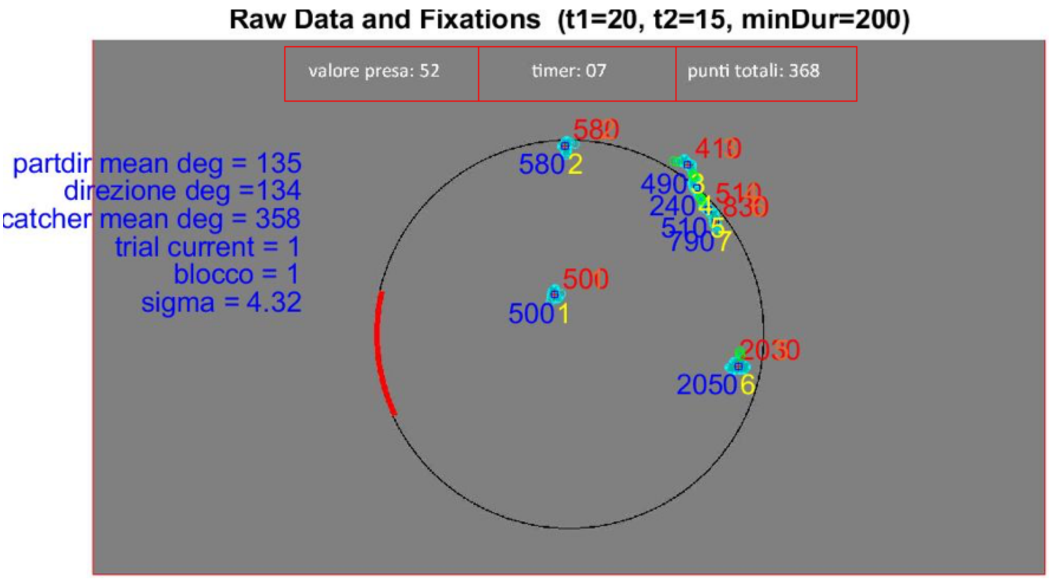

Figure 4.5: An example of fixations made by a participant. In the Top area, there are some information about the task, such as the value of the bucket, the time remained to make a response and the score gained until that moment.

ter in Medium compared to Large σ^* ($t(4721) = 16.04$, $p < .0001$). However, single factors Type of Sport and Experimental Session were nonsignificant ($F(2,69) = 0.16$, $p > .05$; $F(1,4721) = 1.85$, $p > .05$, respectively). Intelligence factor highlighted a trend toward significance ($F(1,69) = 3.41, p.07$), where SE was slightly better for Raven A than Raven B participants. The single factor Session was significant ($F(1,4721) = 15.84, p < .0001$), where SE was better in the First Session compared to the Second Session.

Interactions Type of Sport × Condition($F(4,4721) = 1.85$, $p > .05$), Type of Sport × Experimental Session ($F(2,4721) = 1.73$, $p > .05$). Experimental Session × Intelligence ($F(1,4721) = 1.18$, $p > .05$) were nonsignificant. However, interactions Condition × Experimental Session and Condition × Intelligence were significant ($F(2,4721) = 4.50$, $p = .01$; $F(1,4721) = 11.72, p < .0001$, respectively). Post-hoc analysis on interaction Condition × Experimental Session revealed no-differences between High Pressure Session and Low Pressure Session in Tight, Medium and Large σ^* ($t(4721) < 2.49$, $p > .05$). However, in both the experimental sessions *SE* was better in Tight compared to Medium and Large σ^* (Tight VS Medium σ^*: HPS: $t(4721) = 9.36$, $p < .0001$; LPS: $t(4721) = 10.39$, $p < .0001$; Tight VS Large σ^*: HPS: $t(4721) = 22.74$, $p < .0001$; LPS: $t(4721) = 19.62$, $p < .0001$). Moreover, *SE* was better in Medium compared to Large σ^* (HPS: $t(4721) = 13.38$, $p < .0001$; LPS: $t(4721) = 9.31$, $p < .0001$). Post-hoc analysis on interaction Condition × Intelligence revealed Raven A participants had a better *SE* than Raven B participants in Tight σ^* ($t(89.3) = 3.06$, $p = .03$), while in the other two σ^*s no-difference between the two groups emerged (Medium σ^*: $t(89.3) = 1.87$, $p > .05$; $t(89.3) = 0.27$, $p > .05$). Furthermore, post-hoc analysis revealed, for both the groups, that *SE* was better in Tight σ^* compared to Medium and Large σ^* (Raven A: $t(4721) = 11.20$, $p < .0001$; Raven B; $t(4721) = 9.20$, $p < .0001$; Raven A: $t(4721) = 24.35$, $p < .0001$; Raven B: $t(4721) = 19.49$, $p < .0001$, respectively). Moreover, *SE* was better Medium compared to Large σ^* ($t(4721) = 13.13$, $p < .0001$; $t(4721) = 10.29$, $p < .0001$).

Triple interactions Condition × Type of Sport × Experimental Session and Condition × Intelligence × Experimental Session were significant ($F(4,4721) = 4.42$, $p = .002$; $F(2,4721) = 6.83$, $p = .001$, respectively).

Post-hoc analysis of triple interaction Condition × Type of Sport × Experimental Session highlighted that there were no-differences among the three groups in the three σ^*s in both HPS and LPS ($t(125) < 1.95$, $p > .05$, Fig. 4.6). Additionally, no-differences between HPS and LPS in the three σ^*s for both OSG and CSG were found ($t(4721) < 2.97$, $p > .05$). Whereas the analysis highlighted a trend towards significance between HPS and LPS for CG in Tight σ^*, where *SE* was better in HPS compared to LPS ($t(4721) = 3.11$, $p = .08$). No differences emerged in the other two σ^*s between LPS and HPS ($t(4721) < 1.27$, $p > .05$). However, all groups in both HPS and LPS had a better *SE* in Tight σ^* compared to Medium and Large σ^*. Furthermore, the analysis showed that in all the groups, *SE* was better in Tight compared to Medium and Large σ^* and in Medium compared to Large in both the experimental sessions σ^* ($t(4721) > 4.44$, $p < .01$).

Post-hoc analysis on interaction Condition × Intelligence × Experimental Session revealed differences between Raven A and Raven B only in LPS and in Tight σ^* ($t(125) = 4.21, p = .001$). In the two σ^*s and in HPS in all the three σ^* no differences were found ($t(125) < 1.81, p > .05$). Furthermore, the analysis highlighted no-differences between HPS and LPS for Raven A in the three σ^*s ($t(4721) < 1.91$, $p > .05$). Results on Raven B participant, instead, showed better *SE* in HPS compared to LSP ($t(4721) = 3.61$, $p = .007$). In the other two σ^*s no difference between the two experimental sessions emerged (Medium σ^*: $t(4721) = 2.04$, $p > .05$;

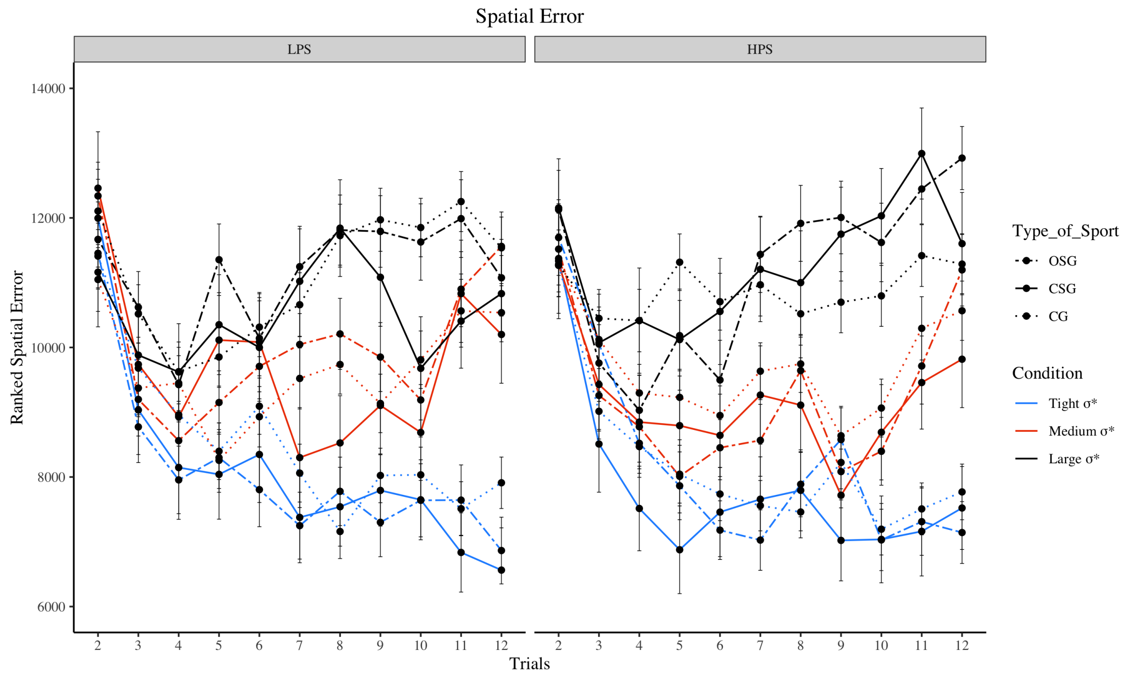

Figure 4.6: OSG, CSG and CG *Spatial Error* in the three conditions (σ^*). The chart reports ranked *SE* average and SEM for each trial, for each σ^*. Fig. 4.7 shows *SE* in the three σ^*s separately.

Large σ^*: $t(4721) = 2.08$, $p > .05$). Additionally, post-hoc analysis revealed that both the groups in both experimental sessions had better *SE* in Tight σ^* compared to Medium and Large σ^* as well as it was better in Medium than Large σ^* ($t(4721) > 5.30$, $p < .01$). Trial factor as well as its interaction with Condition were significant ($F(10,4692) = 36.76$, $p < .0001$; $F(20,4692) = 16.22$, $p < .0001$, respectively). In order to test time effect (Trial factor) as performed in Chapter 2 and Chapter 3, we performed three linear mixed-effects model regressions for each σ^*. Trial factor in Tight, Medium and Large σ^* was significant ($F(10,1523) = 39.06$, $p < .0001$; $F(10,1523) = 19.52$, $p < .0001$; $F(10,1523) = 12,34$, $p < .0001$, respectively).

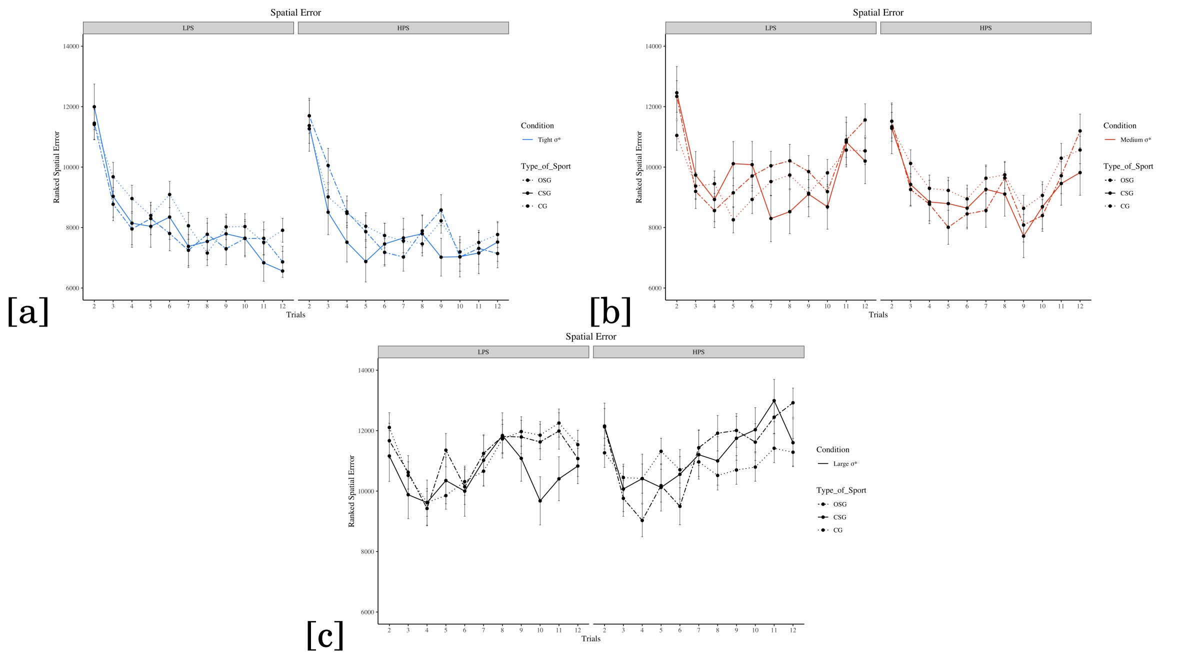

Figure 4.7: Fig. 4.7a shows *SE* (Eq. 1.1) in the Tight σ^* where the uncertainty was low; Fig. 4.7b *SE* shows the Medium σ^* while Fig. 4.7c shows SE in the condition that was characterised by high variability (Large σ^*).

Post-hoc analyses are reported in Table 4.1, Table 4.2 and Table 4.3 in Supplemental Information Sub-Chapter (4.5). Analysis revealed that triple interaction Trial × Condition × Experimental Session was significant ($F(20,4670) = 1.94$, $p = .01$). Post-hoc analysis for each σ^* in each experimental session revealed significant differences ($F > 3.30$, $p < .05$). Post-hoc analyses are reported in tables 4.4, 4.5, 4.6, 4.7 and 4.8, 4.9, respectively.

4.3.2.2 Gain

Step-wise regression on *Gain* revealed single factor Intelligence and its interaction with Condition and Experimental Session were not significant

($F < 1.02$, $p > .05$).

Final mixed-effect regression model revealed a significant effect of Condition ($F(2,4667) = 710.53$, $p < .0001$).

Post-hoc analysis revealed *Gain* was higher in Tight σ^* compared to Medium and Large σ^* ($t(4667) = 19.58$, $p < .0001$; $t(4667) = 37.69$, $p < .0001$, respectively). Moreover, *Gain* was higher in Medium compared to Large σ^* ($t(4667) = 17.46$, $p < .0001$). Single factor Experimental Session revealed better *Gain* in HPS compared to LPS ($F(1,4667) = 11.44$, $p = .001$). Moreover, the analysis revealed the single factor Session was significant ($F(1,4667) = 18.96, p < .0001$). In particular, the analysis revealed better *Gain* in the Second Session compared to the First one.

Type of Sport factor was not significant ($F(2,70) = 1.06$, $p > .05$). Also its interaction with Condition ($F(4,4667) = 0.34$, $p > .05$) as well as its interaction with Experimental Session ($F(2,4667) = 1.30$, $p > .05$). Moreover, interaction Condition × Experimental Session was not significant ($F(2,4670) = 2.13$, $p > .05$).

Interaction Condition × Session was significant ($F(2,4667) = 9.22, p = .0001$). The post-hoc analysis revealed differences between First and Second Session in Medium and Large σ^* ($t(4667) = 5.30$, $p < .0001$; $t(4667) = 2.96$, $p = .03$). The *Gain* was higher in second sessions compared to first sessions. No differences between the two sessions in Tight σ^* were found ($t(4667) = 0.72$, $p > .05$). Moreover, the post-hoc analysis revealed better *Gain* in Tight compared to Medium and Large σ^* and in Medium compared to Large σ^* i both First and Second Session ($t(4667) > 11.50$, $p < .0001$).

Triple interaction Condition × Type of Sport × Experimental Session was significant ($F(4,4667) = 3.51$, $p = .007$, Fig 4.8). Post-hoc analysis revealed no-differences among the three experimental groups in the three σ^*s and in both HPS and LPS ($t < 2.55$, $p > .05$). Moreover, results highlighted OSG were able to gain more points in the Medium σ^* when exposed to HPS compared to LPS ($t(4667) = 4.29$, $p = .001$) while CG participants were able to gain more points in Tight σ^* when exposed to LPS compared to HPS ($t(4667) = 3.96$, $p = .003$). No-differences in the other conditions were found ($t(4667) < 1.70$, $p > .05$). CSG results highlighted no-difference between the two experimental sessions in the three σ^*s ($t < 0.85$, $p > .05$). Moreover, the results showed all groups had better *Gain* in Tight compared to Medium and Large σ^* ($t(4667) > 4.91$, $p < .05$) as well as *Gain* was better in Medium compared to Large σ^* ($t(4667) > 5.77$, $p < .0001$) in both LPS and HPS.

Trial factor and its interaction with Condition and its interaction with Session were significant ($F(9,4218) = 15.49$, $p < .0001$; $F(18,4218) = 6.24$, $p < .0001$; $F(9,4218) = 2.98$, $p = .002$, respectively). Moreover, the analysis revealed the interactions Trial × Condition × Experimental Session and Trial × Condition × Session were significant ($F(18,4218) = 1.80$, $p = .02$; $F(18,4218) = 5.41$, $p < .0001$, respectively).

Post-hoc analysis was performed only in triple interaction Trial ×

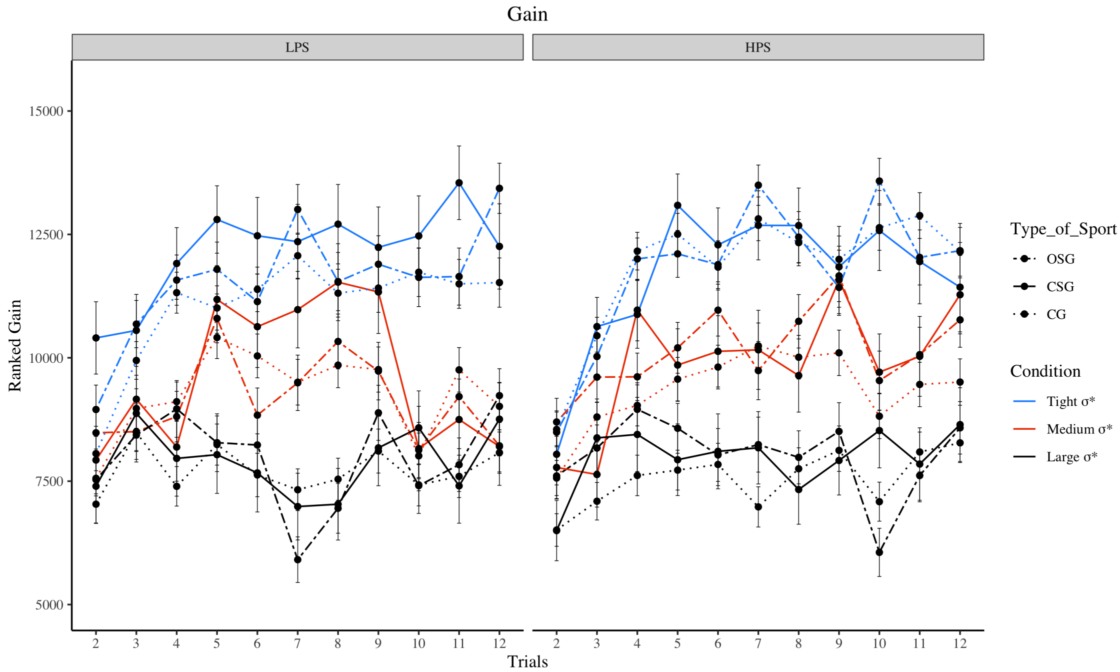

Figure 4.8: The figure shows OSG, CSG and CG *Gain* parameter in the three conditions (σ^*s). The chart reports *Gain* average and SEM for each trial of three experimental groups. In Fig. 4.9 it is possible to view *Gain* in the three σ^*s separately.

Condition × Experimental Session. For each σ^* and for each Experimental Session, we create a linear mixed-effect regression model.

Analysis in Tight σ^* on both LPS and HPS revealed Trial factor was significant ($F(10,720) = 6.75$, $p < .0001$, $F(10,720) = 11.75$, $p < .0001$, respectively). Both post-hoc analyses are reported in Table 4.13 and in Table 4.14 of SI Sub-chapter 4.5.2). In Medium σ^* both in LPS and HPS Trial factor was significant ($F(10,720) = 8.13$, $p < .0001$; $F(10,720) = 5.01$, $p < .0001$, respectively). Post-hoc analyses of both LPS and HPS are reported in Table 4.15, 4.16 of SI (Chapter (4.5), Sub-chapter (4.5). Analysis on Large σ^* revealed both in LPS and HPS the Single factor trial

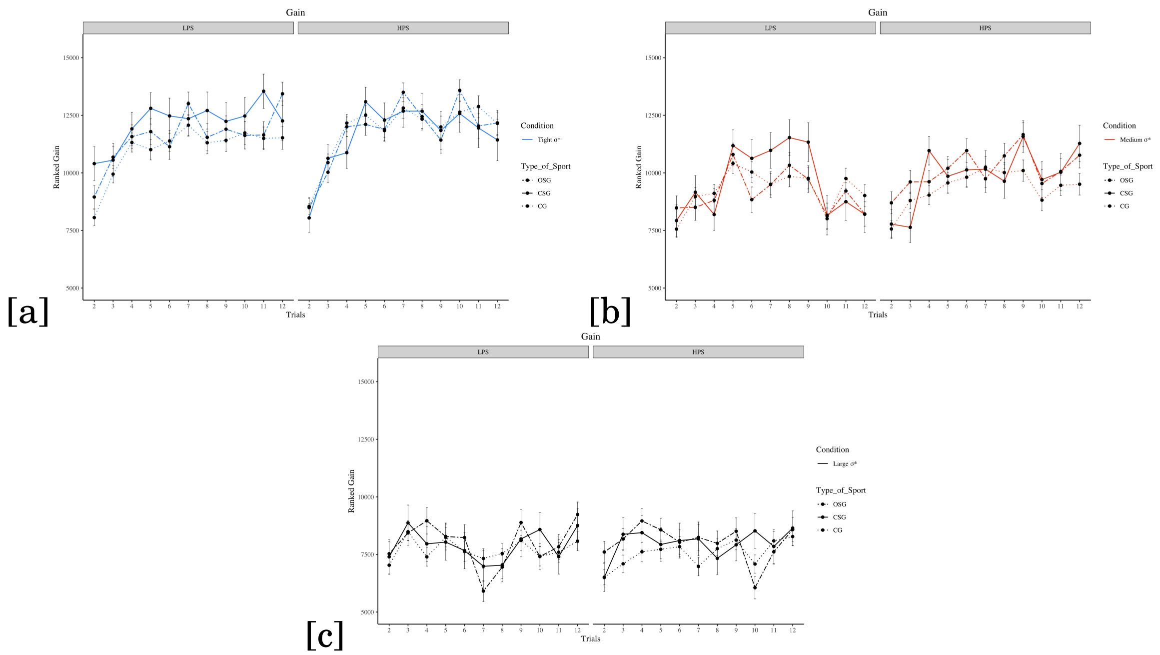

Figure 4.9: In the charts are reported the *Gain* average and SEM for each trial and for each σ^* of CSG, OSG and CG. Fig. 4.9a shows *Gain* parameter in Tight σ^* where the uncertainty was low; Fig. 4.9b shows *Gain* in Medium σ^* while Fig. 4.11c shows *Gain* in the Large condition which was characterised by high variability.

was significant ($F(10,270) = 5.05$, $p < .0001$; $F(10,720) = 3.30$, $p = .0003$, respectively). Post-hoc analyses are reported in Tables 4.17 and 4.18 of SI Sub-chapter 4.5.2).

4.3.2.3 Gain Error

Step-wise regression in linear mixed-effects regression model on *Gain Error* revealed the single factor Condition was significant ($F(2,4218) = 35.20$, $p < .0001$). Post-hoc analysis revealed no-differences between Tight and Medium σ^* ($t(4218) = 0.98$, $p > .05$). However, *Gain Error* was better in Tight and Medium σ^* compared to Large σ^* ($t(4218) = 7.71$, $p < .0001$;

$t(4218) = 6.72$, $p < .0001$, respectively).

Analysis revealed Experimental Session factor was significant where *Gain Error* was better in HPS compared to LPS ($F(1,4218) = 10.33$, $p = .001$). Also single factor Session was significant ($F(1,4218) = 9.38$, $p = .002$). *Gain Error* was better in in second compared to the first session. The interaction Trial × Condition ($F(9,4218) = 2.98$, $p = .002$) as well as the triple interactions Trial × Condition × Experimental Session ($F(18,4218) = 2.80$, $p = .02$) and Trial × Condition × Session ($F(18,4218) = 4.41$, $p < .0001$) were significant. Post-hoc analysis was

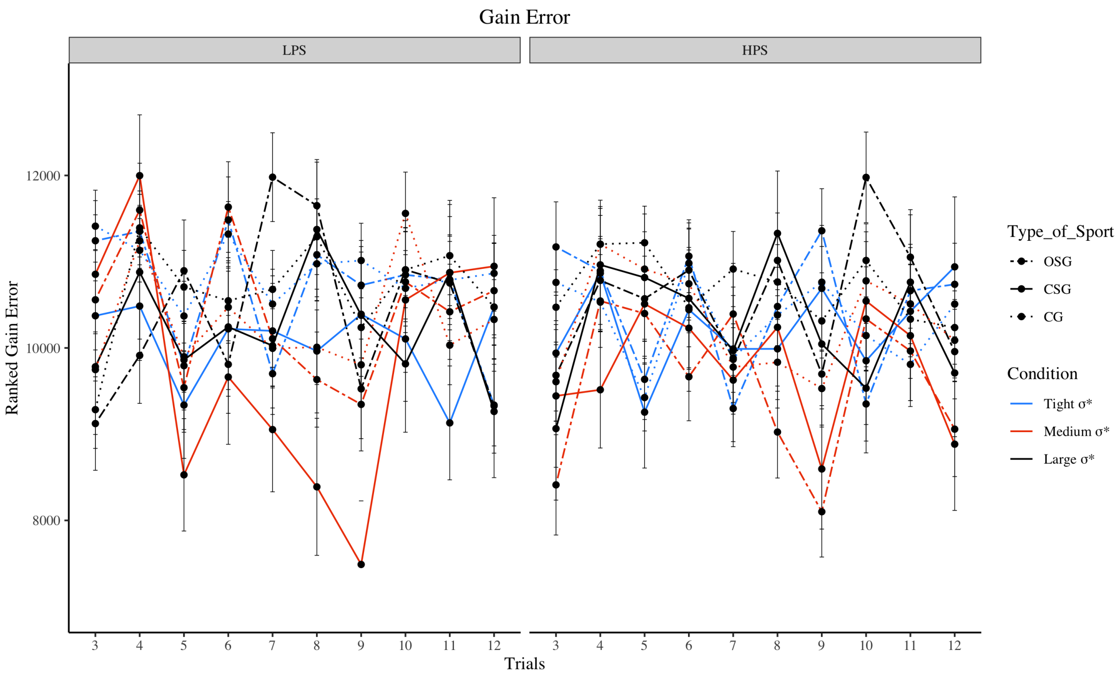

Figure 4.10: OSG and CSG and CG *Gain Error* in the three conditions (σ^*s). The charts reported Log transformed *Gain Error* average and SEM for each Trial of CSG, OSG and CG. Fig. 4.11 shows *Gain Error* in the three σ^* separately.

performed only in triple interaction Trial × Condition × Experimental

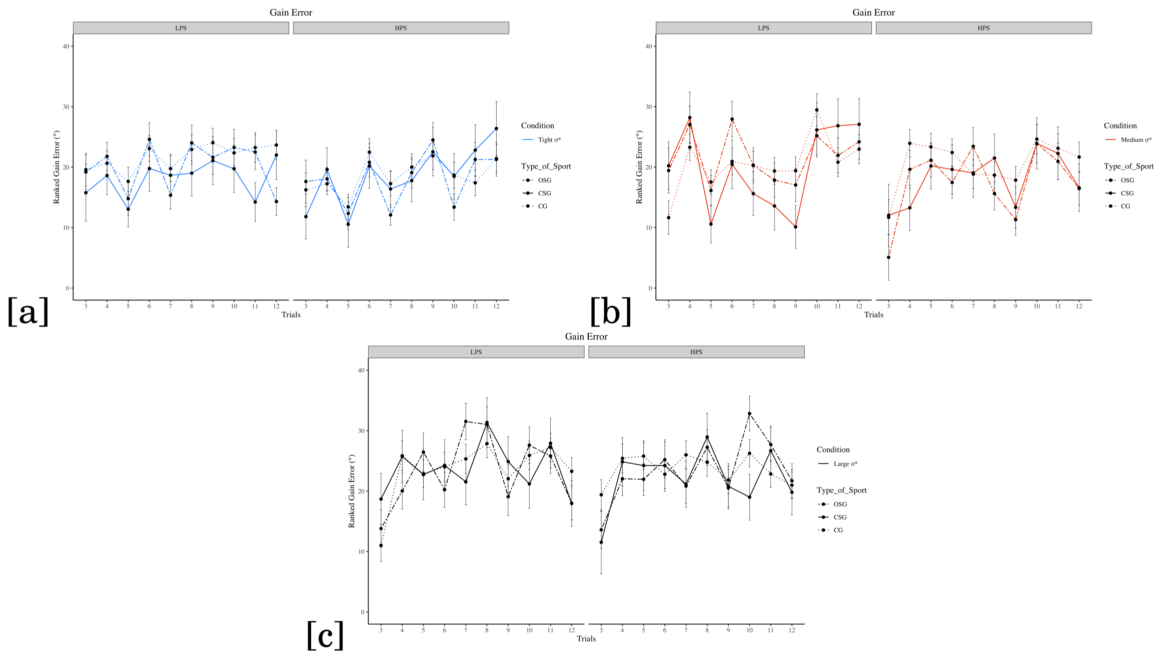

Figure 4.11: In the charts are reported *Gain Error* average and SEM for each trial for CSG and OSG. Fig. 4.11a shows *Gain Error* parameter in Tight σ^* where the uncertainty was low; Fig. 4.11b shows *Gain Error* in Medium σ^* while Fig. 4.11c shows *Gain Error* in the Large condition where high variability was present.

Session. For each σ^* and for each Experimental Session, we create a linear mixed-effect regression model. In all the σ^*s and in both LPS and HPS, the Trial effect was significant (Tight σ^*, LPS: $F(9,648) = 2.95$, $p = 01$; HPS: $F(9,648) = 4.50$, $p < .0001$; Medium σ^*, LPS: $F(9,648) = 6.48$, $p < .0001$; HPS ($F(9,648) = 5.75$, $p < .0001$; Large σ^*, LPS: $F(9,648) = 6.58$, $p < .0001$; HPS: $F(9,648) = 3.95$, $p < .0001$). Post-hoc analyses are reported in tables 4.19, 4.20, 4.21, 4.22, 4.23 and 4.24 of Supplemental Information Sub-chapter (Sub-section 4.5.3)

4.3.2.4 Standard Deviation Error (SD-E)

Step-wise regression on *SD-E* revealed single factor Condition was significant ($F(2,4275) = 377.18$, $p < .0001$). In particular, post-hoc analysis revealed *SD-E* was better in Large compared to Medium and Tight σ^* ($t(4275) = 19.42$, $p < .0001$; $t(4275) = 26.52$, $p < .0001$, respectively). Moreover, *SD-E* was better in Medium compared to Tight σ^* ($t(4275) = 7.11$, $p < .0001$).

Single factors Type of Sport and Intelligence were nonsignificant ($F(2,69) = 0.30$, $p > .05$; $F(1,69) = 1.52$, $p > .05$, respectively). However, single factor Experimental Session revealed better *SD-E* in LPS compared to HPS ($F(2,4275) = 167.29$, $p < .0001$). Also single factor Session was significant where the *SD-E* was better in the First Session compared to the Second Session ($F(1,4275) = 55.68$, $p < .0001$). Interaction Condition × Type of Sport was significant $(4,4275) = 7.92$, $p < .0001$). However, the post-hoc analysis revealed no-differences in the three σ^*s among the three experimental groups ($t(71.9) < 1.30$, $p > .05$). Moreover, the post-hoc analysis revealed OSG and CG had better *SD-E* in Large compared to Medium and Tight σ^* OSG:($t(4275) = 7.20$, $p < .0001$; $t(4275) = 20.37$, $p < .0001$; CG: $t(4275) = 3.87$, $p = .002$; $t(4275) = 16.43$, $p < .0001$) as well as *SD-E* was better in Medium compared to Tight σ^* (OSG: $t(4275) = 13.04$, $p < .0001$; CSG: $t(4275) = 12.44$, $p < .0001$).

Analysis on CSG showed no-differences between Large and Medium σ^* ($t(4275) = 2.13$, $p > .05$) while *SD-E* was better Large compared to

Tight σ^* ($t(4275) = 11.62$, $p < .0001$). Furthermore, analysis highlighted a better *SD-E* in Medium compared Tight σ^* ($t(4275) = 9.49$, $p < .0001$).

Interaction Condition × Experimental Session was significant ($F(2,4281) = 2.88$, $p = .04$). Post-hoc analysis revealed no-differences between the experimental sessions in Tight and Medium σ^* ($t(4275) = 1.91$, $p > .05$; $t(4275) = 2.41$, $p > .05$, respectively). However, in Large σ^* *SD-E* was better in LPS compared to HPS ($t(4275) = 5.21$, $p < .0001$). Moreover, post-hoc analysis revealed that in both experimental sessions *SD-E* was better in Large compared to Medium and Tight σ^* (LPS: $t(4275) = 6.36$, $p < .0001$; $t(4275) = 20.15$, $p < .0001$; HPS: $t(4275) = 3.61$, $p = .003$; $t(4275) = 17.06$, $p < .001$). The analysis revealed also better *SD-E* in Medium compared to Tight σ^* (LPS: $t(4275) = 13.97$, $p < .0001$; HPS: $t(4275) = 13.48$, $p < .0001$).

Interaction Type of Sport × Experimental Session was significant ($F(2,4275) = 4.86$, $p = .008$). Post-hoc analysis revealed OSG and CSG had a better *SD-E* in LPS compared to HPS ($t(4275) = 4.24$, $p = .0002$; $t(4275) = 3.72$, $p = .002$, respectively). Whereas no-differences between the two experimental sessions in CG were found ($t(4275) = 1.20$, $p > .05$). Furthermore, the analysis showed no-difference among the groups in the two experimental sessions ($t < 0.93$, $p > .05$).

Interaction Condition × Intelligence was significant ($F(2,4275) = 14.01$, $p < .0001$). Post-hoc analysis revealed that both Raven A and Raven B groups had better *SD-E* in LPS compared to HPS ($t(4275) = 5.31$, $p < .0001$; $t(4275) = 2.67$, $p < .03$, respectively). Whereas no-differences between Raven A and Raven B in both LPS and HPS emerged ($t(70.5) = 1.44$, $p > .05$; $t(70.5) = 1.01$, $p > .05$, respectively).

Interaction Condition × Session was significant ($F(2,4275) = 10.60$, $p < .0001$). The post-hoc analysis revealed *SD-E* was better in the First Session compared to the Second Session in the Tight and Large σ^*s ($t(4273) > 4.40$, $p < .0001$). No differences emerged between the two sessions emerged in Medium σ^* ($t(4273) = 1.01$, $p > .05$). Moreover the post-hoc analysis revealed that in both the sessions the *SD-E* was better in Large σ^* compared to Tight σ^* (First Session: $t(4273) = 17.85$, $p < .0001$; Second Session: $t(4273) = 20.85$, $p < .0001$) and compared to Medium σ^* (First Session: $t(4273) = 6.72$, $p < .0001$; Second Session: $t(4273) = 3.51$, $p = .004$). Furthermore, the analysis revealed a better *SD-E* in Medium compared to Tight σ^* (First Session: $t(4273) = 11.08$, $p < .0001$; Second Session: $t(4273) = 17.34$, $p < .0001$).

Additionally, final linear mixed-effects regression model revealed that Condition × Type of Sport × Experimental Session was significant ($F(4,4275) = 6.92$, $p < .0001$, Fig. 4.12). Post-hoc analysis highlighted no-differences among the groups in the three σ^*s and between the two experimental sessions ($t < 1.62$, $p > .05$). Moreover, the analysis revealed that OSG in LPS had a better *SD-E* in Large compared to Medium and Tight σ^* ($t(4273) = 8.08$, $p < .0001$; $t(4273) = 14.49$, $p < .0001$, respectively). Moreover, *SD-E* was better in Medium compared to Tight σ^* ($t(4273) = 6.41$, $p < .0001$). In HPS instead, the analysis revealed no-differences between

Large and Medium σ^* ($t(4273) = 2.18$, $p > .05$). However, *SD-E* was better in Large and Medium σ^* compared to Tight σ^* ($t(4273) = 14.46$, $p < .0001$; $t(4273) = 12.27$, $p < .0001$).

Post-hoc analysis on CSG in LPS and HPS indicated no-differences between Large and Medium σ^* (LPS: $t(4273) = 0.75$, $p > .05$; HPS: $t(4273) = 1.90$, $p > .05$, respectively). However, in both experimental sessions *SD-E* was better in Large and Medium σ^* compared Tight σ^* (Large VS Tight σ^*, LPS: $t(4273) = 9.45$, $p < .0001$; HPS: $t(4273) = 6.39$, $p < .0001$; Medium VS Tight σ^*, LPS: $t(4273) = 9.41$, $p < .0001$; HPS: $t(4273) = 4.49$, $p = .0003$). Post-hoc analysis on CG revealed in LPS that *SD-E* was better in Large compared to Medium and Tight σ^* ($t(4273) = 3.35$, $p = .04$; $t(4273) = 13.00$, $p < .0001$, respectively). Furthermore, *SD-E* was better in Medium compared to Tight σ^* ($t(4273) = 9.65$, $p < .0001$). In HPS, no-differences in *SD-E* between Large and Medium σ^* emerged ($t(4273) = 1.90$, $p > .05$). However, *SD-E* was better in Medium and Large σ^* compared to Tight σ ($t(4273) = 10.47$, $p < .0001$; $t(4273) = 8.21$, $p < .0001$). Post-hoc analysis also revealed for OSG that *SD-E* in Tight σ^* was better in LPS compared to HPS ($t(4273) = 4.40$, $p = .001$). In Medium σ^* no-differences emerged between LPS and HPS ($t(4273) = 1.47$, $p > .05$) while in Large σ^*, the *SD-E* was different between the two experimental sessions ($t(4273) = 4.43$, $p = .0004$). In particular, in LPS OSG shrink the bucket M = 1.03°, SE = 0.69° more than necessary, while in in HPS the narrowed the bucket M = −1.32° SD = 0.73° more than necessary. The post-hoc analysis on CSG revealed no differences between the two experimental session in Tight and Large σ^* ($t(4273) = 0.23$, $p > .05$; $t(4273) = 2.78$, $p > .05$). In Medium σ^* instead, the *SD-E* was better in LPS compared to HPS ($t(4273) = 3.92$, $p = .004$). The post-hoc analysis on CG revealed a similar behaviour in *SD-E* between the two experimental sessions in the three σ^*s ($t(4273) < 1.90$, $p > .05$).

Triple interaction Condition × Intelligence × Experimental Session was significant ($F(4275) = 3.45$, $p = .03$). The post-hoc analysis revealed no-differences between the two experimental sessions and between Raven A and Raven B in each σ^* ($t(75.2) < 1.86$, $p > .05$). The post-hoc analysis on *SD-E* revealed in Raven B group there were no-differences between LPS and HPS in each σ^* ($t(4273) = 2.47$, $p > .05$). In Raven A, instead, the analysis revealed a better *SD-E* in LPS compared to HPS ($t(4273) = 5.31$, $p < .0001$). In the other two σ^*s instead, no differences emerged (Tight σ^*: $t(4273) = 2.80$, $p > .05$; Medium: σ^* $t(4273) = 1.11$, $p > .05$). In Raven B group in both LPS and HPS, the *SD-E* was better in Large compared to Medium and Tight σ^* (LPS: Large VS Medium, σ^* $t(4273) = 5.89$, $p < .0001$; Large VS Tight σ^* ($t(4273) = 17.17$, $p < .0001$; HPS: Large VS Medium σ^*, $t(4273) = 6.12$, $p < .0001$; Large VS Tight σ^*, $t(4273) = 14.85$, $p < .0001$). Furthermore, *SD-E* was better in Medium compared to Tight σ^* (LPS: $t(4273) = 11.28$, $p < .0001$; HPS: $t(4273) = 8.73$, $p < .0001$). Similar results in Raven A group were found. In LPS *SD-E* was better in Large compared to Medium and Tight σ^* (Large VS Medium σ^* $t(4273) =$

3.48. $p = .01$; Large VS Tight σ^*, $t(4273) = 12.66$, $p < .0001$). Moreover, *SD-E* was better in Medium compared to Tight σ^* ($t(4273) = 9.18$, $p < .0001$). In HPS no-differences between Large and Medium σ^* ($t(4273) = 0.73$, $p > .05$) while the *SD-E* was better in Large compared to Tight σ^* and it was better in Medium compared to Tight σ^* ($t(4273) = 10.14$, $p < .0001$; $t(4273) = 10.87$, $p < .0001$).

Furthermore, linear mixed-effects analysis highlighted single factor Trial was significant ($F(9,4275) = 167.29$, $p < .0001$) as well as its interaction with Condition ($F(18,4260) = 9.31$, $p < .0001$). Analysis Tight, Medium and Large σ^* revealed a significant effect for Trial factor (Tight σ^*: $F(9,1378) = 61.05$, $p < .0001$; Medium σ^*: $F(9,1378) = 28.87$, $p < .0001$; Large σ^*: $F(9,1378) = 4.52$, $p < .0001$). Post-hoc analyses for each σ^* are reported in Table 4.26, 4.27 and 4.28 of S.I. Sub-chapter 4.5 (Sub-section 4.5.5).

4.3.2.5 Bucket's length - σ^U

Step-wise regression in linear mixed-effect regression model analysis for σ^U revealed Condition factor was significant ($F(2,4260) = 341.02$, $p < .0001$).

In deep analysis revealed σ^U was shorter in Tight σ^* compared to Medium and Large σ^* ($t(4273) = 19.35$, $p < .0001$; $t(4273) = 26.34$, $p < .0001$, respectively) as well as σ^U was shorter in Medium compared to Large σ^* ($t(4273) = 6.99$, $p < .0001$). Type of Sport and Intelligence fac-

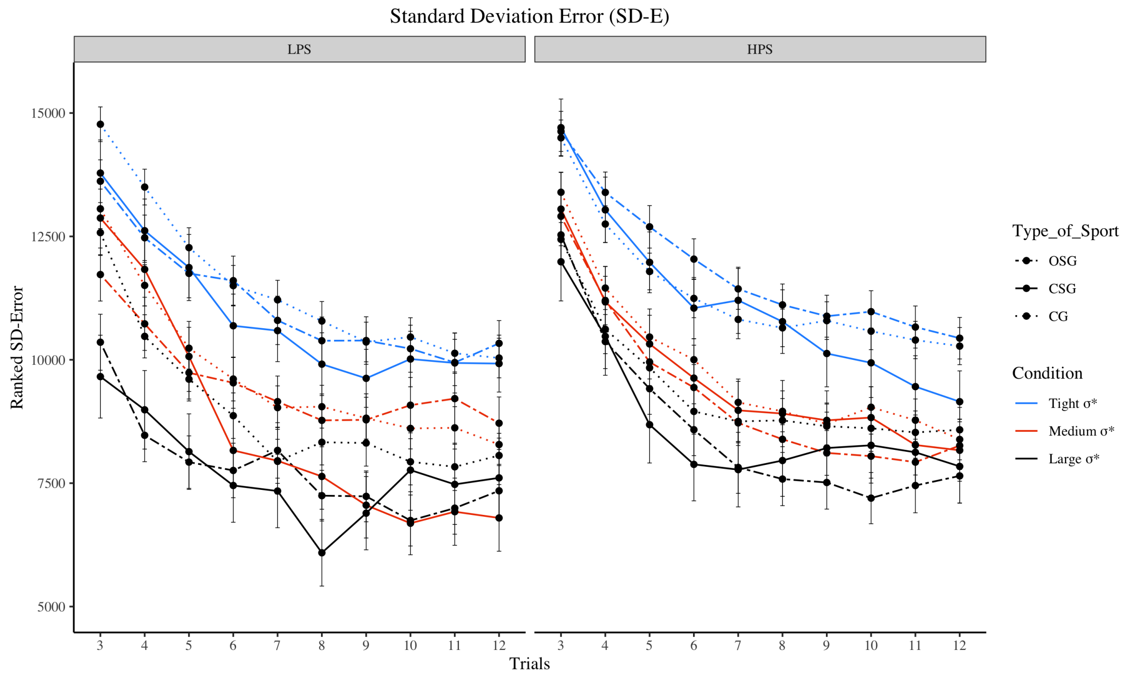

Figure 4.12: Figure shows OSG, CSG and CG *SD-E* (Eq. **??**) in the three conditions (σ^*s). The chart reports the *SD-E* ranked average and SEM for each Trial of OSG and CSG. In Fig. 4.13 it is possible to view *SD-E* in the three σ^*s separately.

tors were nonsignificant ($t(2,69) = 0.31$, $p > .05$; $t(1,69) = 1.60$, $p > .05$, respectively). Whereas, Condition and Session factors were significant ($F(1,4260) = 8.99$, $p = .003$; $F(1,4260) = 43.80$, $p < .0001$). In particular, the length of the bucket was larger in HPS compared to LPS and its was larger in the Second Session compared to the First one.

Interaction Condition × Type of Sport was significant ($F(4,4260) = 7.07$, $p < .0001$). Post-hoc analysis revealed no-differences in the three σ^*s among the experimental groups ($t(71.7) < 1.27$, $p > .05$). Moreover, the post-hoc analysis reported OSG, CSG and CG had a shorter σ^U in Tight σ^* compared to Medium σ^* (OSG: $t(4260) = 7.44$, $p < .0001$; CSG:

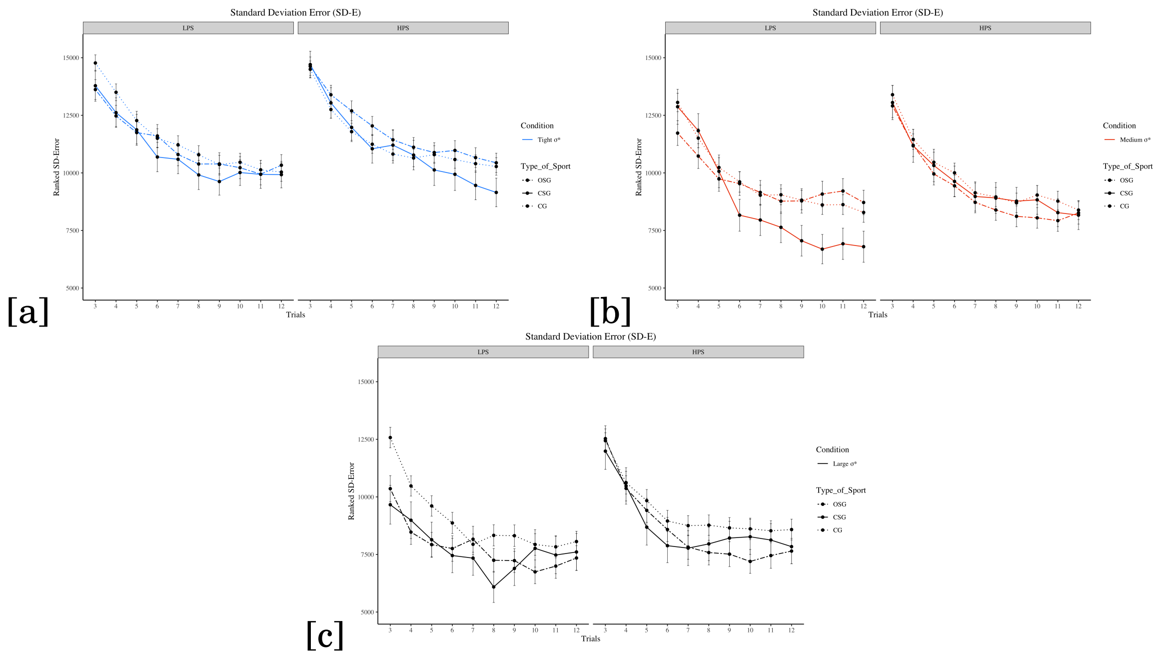

Figure 4.13: *SD-E* ranked average and SEM for each Trial of OSG, CSG and CG. Fig. 4.13a shows *SD-E* parameter in the Tight σ^* where the uncertainty was low; Fig. 4.13b shows *SD-E* in the Medium σ^*, while Fig. 4.13c shows *SD-E* in the Large condition where high variability was present.

$t(4260) = 5.60$, $p < .0001$; CG: $t(4260) = 12.91$, $p < .0001$) as well as when it was compared to the Large σ^* (OSG: $t(4260) = 12.44$, $p < .0001$; CSG: $t(4260) = 11.75$, $p < .0001$; CG: $t(4260) = 23.35$, $p < .0001$). Moreover, for all the groups σ^U was shorter in Medium compared to Large σ^* (OSG: $t(4260) = 5.00$, $p < .0001$; CSG: $t(4260) = 7.16$, $p < .0001$; CG: $t(4260) = 10.44$, $p < .0001$).

Interaction Condition × Experimental Session was significant ($F(2,4260) = 4.02$, $p = .02$). Post-hoc analysis showed significant differences between HPS and LPS only in Large σ^* ($t(4260) = 4.05$, $p = .001$) where the bucket was larger in HPS compared to LPS. Whereas no-differences between two experimental sessions in both Tight and Medium σ^* were found ($t(4260) = 0.63$, $p > .05$; $t(4260) = 0.51$, $p > .05$). However, the analysis showed that in both experimental sessions, σ^U was shorter in Tight compared to Medium and Large σ^* (LPS: $t(4260) = 9.73$, $p < .0001$; $t(4260) = 16.76$, $p < .0001$, respectively; HPS: $t(4260) = 9.62$, $p < .0001$; $t(4260) = 20.17$, $p < .0001$). Moreover, σ^U was shorter in Medium compared to Large * (LPS: $t(4260) = 7.02$, $p < .0001$; HPS: $t(4260) = 10.55$, $p < .0001$).

Data analysis showed the interaction Type of Sport × Experimental Session was not significant ($F(2,4260) = 1.96$, $p < .0001$). However, the interactions Condition × Intelligence and Condition × Session were significant ($t(2,4260) = 14.39$, $p < .0001$). The post-hoc analysis on interaction Condition × Intelligence revealed the bucket's length of Raven A and Raven B participants in LPS was shorter than HPS ($t(4273) = 5.32$, $p < .0001$; $t(4273) = 2.67$, $p = .04$). Moreover, the post-hoc analysis revealed no differences in both LPS and HPS between Raven A and Raven B group ($t(69.4) = 1.52$, $p > .05$; $t(69.4) = 1.09$, $p > .05$). The post-hoc analysis on interaction Experimental Condition × Session revealed no differences in any comparison ($t < 1.64$, $p > .05$).

Analysis also showed triple interaction Condition × Type of Sport × Experimental Session was significant ($F(4,4260) = 6.62$, $p < .0001$, see Fig. 4.14). Post-hoc analysis showed no significant differences among the groups in both experimental conditions and in the three σ^*s ($t < 1.40$, $p >$

.05). Regarding the post-hoc analysis on σ^U between the two experimental sessions for each group, CG and CSG had a similar σ^U in the three σ^*s ($t(4260) < 2.82$, $p > .05$). OSG, instead, in LPS had a shorter σ^U compared to HPS in Tight and Large σ^* ($t(4260) = 3.25$, $p = .05$; $t(4260) = 3.47$, $p = .02$, respectively). No differences in Medium σ^* emerged ($t(Inf) = 2.65$, $p > .05$). In LPS all the groups had a shorter σ^U in Tight σ^* compared to Medium and Large σ^* ($t(4260) > 5.72$, $p < .05$) except for CG where no-differences between Tight and Medium σ^* emerged ($t(4260) = 2.49, p > .05$). Moreover, the analysis revealed in all the groups had a shorter bucket in Medium compared to Large σ^* () except for OSG where no differences between the Medium and Large σ^* were found ($t(4260) = 0.50$, $p > .05$). In HPS all experimental groups, except for OSG where no-difference between Tight and Medium σ^* occurred ($t(4260) = 2.32, p > .05$), had a shorter σ^U in Tight compared to Medium and Large σ^* ($t(4260) > 5.11$, $p < .001$). Single factor Trial was significant ($F(9, 4260) = 62.44$, $p < .0001$) as well its interaction with Condition ($F(18, 4260) = 9.31$, $p < .0001$). Three separate linear mixed-effect regression models for each σ^* were computed. Analysis on Tight, Medium and Large σ^*, Trial factor was significant ($F(9, 1378) = 61.05$, $p < .0001$; $F(9, 1378) = 28.87$, $p < .0001$; $F(9, 1378) = 4.52$, $p < .0001$, respectively). Post-hoc analyses are reported in Table 4.26 (tight σ^*), Table 4.27 (Medium σ^*) and Table 4.28 (Large σ^*) of S.I. Sub-chapter 4.5 (Sub-section 4.5.5).

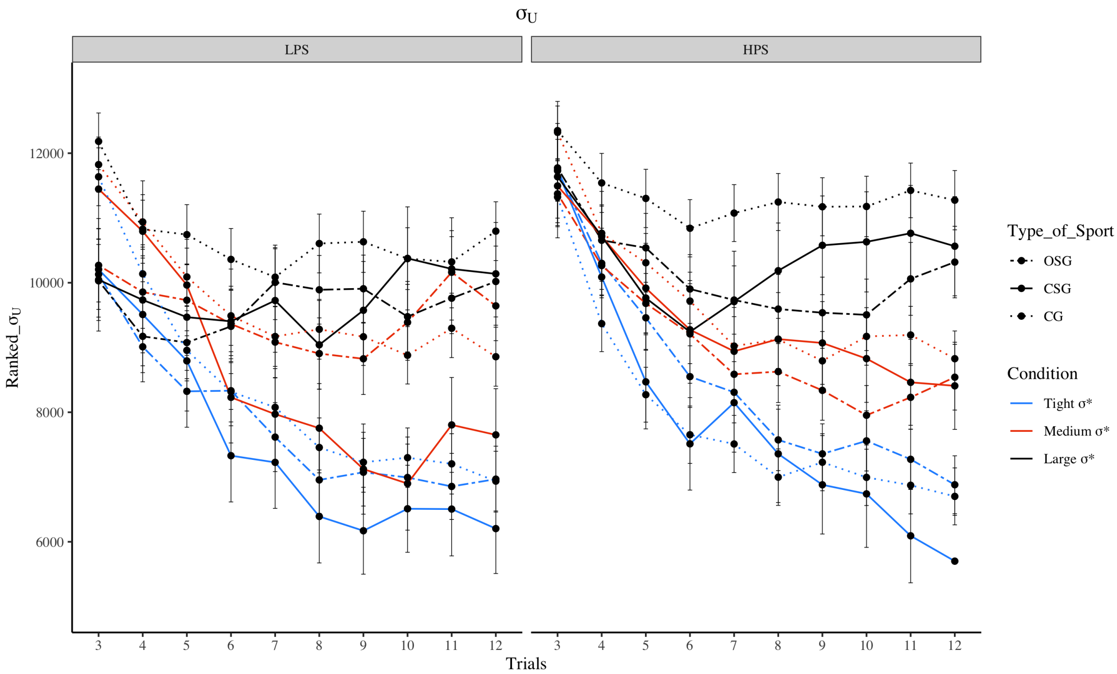

Figure 4.14: OSG and CSG σ^U in the three conditions (σ^*s). The chart reports the σ^U ranked average and SEM for each Trial of CSG and OSG. In Fig. 4.15 it is possible to view σ^U in the three σ^*s separately.

4.4 Discussion and Conclusion

Athletes and especially expert athletes seem to have superior perceptual-cognitive skills both in specific and general domains (Mann et al., 2007; Russo and Ottoboni, 2019; Scharfen and Memmert, 2019; Williams and Ericsson, 2005; Voss et al., 2010). However, in generic domains, researchers have focused their attention on basic cognitive function, while high order cognitive functions such as problem-solving, reasoning and decision-making are less investigated. Moreover, athletes should compete in very stressful situations (Williams and Elliott, 1999).

This research aimed at analysing the general decision-making abilities

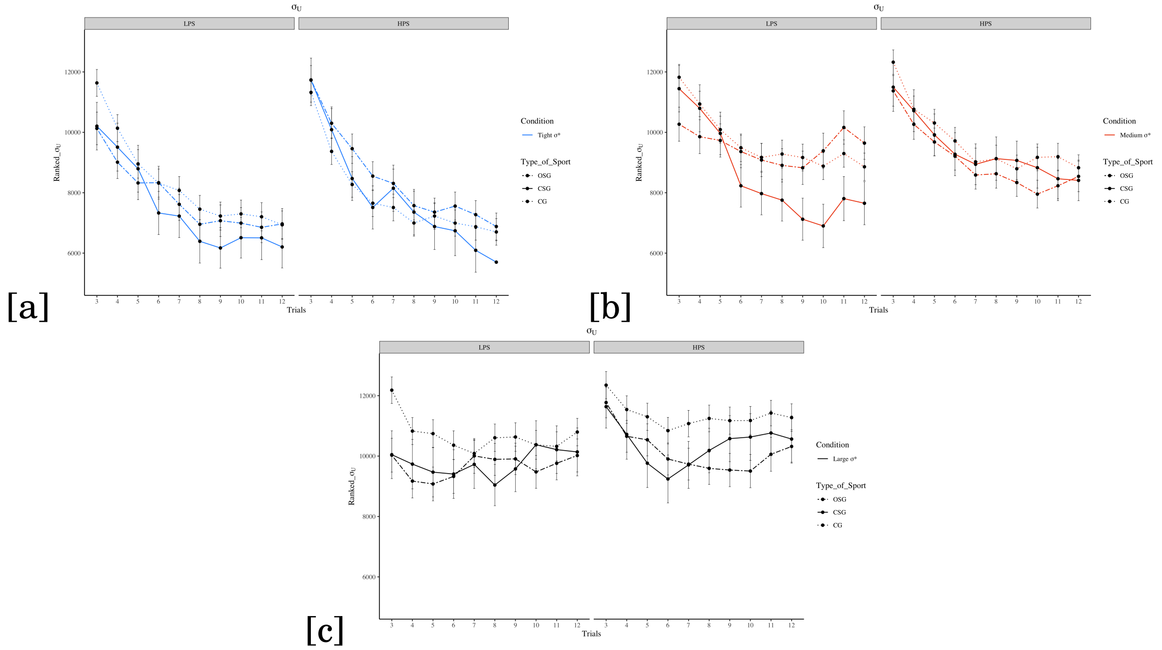

Figure 4.15: σ^U ranked average and SEM for each Trial for the three σ^*s of OSG, CSG and CG. Fig. 4.15a shows σ^U parameter in the Tight σ^* where the uncertainty was low; Fig. 4.15b shows σ^U in the Medium σ^* while Fig. 4.15c shows σ^U in the Large σ^* where high variability was present.

of open- and Closed Skill athletes and how they react when exposed to stressful situations. This choice was given by the fact that athletes should make decisions based on partial information. This is particularly true for open- skill sports compared to closed-skill ones. Furthermore, very often, athletes should make decisions under constrains. In order to control data from athletes, we assessed fluid intelligence, (Raven and Court, 1998) and we recruited a control group of university students.

Analysis of pressure induction was performed through a series of indexes: they were State Anxiety (Spielberger, 1983) (Sub-Chapter 1.3.3), Heart Rate, Mental Effort (Zijlstra, 1993), and eye movements.

Data analysis on pressure induction revealed that pressure induction increase HR and RSME (Zijlstra, 1993). For the former, it was higher in HPS compared to LPS as well as for the latter; the score was higher in HPS compared to LPS. However, state anxiety results revealed no-difference between the two experimental sessions as well as no-differences in the number of fixations and fixation duration emerged. Thus, our hypotheses on pressure induction were partially confirmed. It is very likely that we were able to produce an increase in arousal that perhaps did not lead to a high increment of state anxiety and worry-some toughs.
Another possible limitation is the involvement of the STAI questionnaire (Spielberger, 1983). Probably it was not indicated in these type of experiments as the Competitive State Anxiety Inventory (CSAI-2, Martens et al. 1990).

The decision-task analysis revealed that *SE* performance decreased when the uncertainty increased, and this also happened for *Gain*. Interesting are the *SD-E* and σ^U results; they are similar to Study 1 and Study 2 (Chapter 2 and Chapter 3, respectively) in which, even if participants modulated the bucket's length according to the uncertainty faced when participants faced the low uncertainty environment, participants enlarged the bucket more than necessary compared to the other two conditions. Thus, even in this case, it is possible to assume that participants were forced to enlarge the bucket in order to collect points when the uncertainty was high. In contrast, when the low uncertainty environment was faced, participants had a lower awareness/implicit confidence about the environment that consequently brings to a lower risk tasking (Kepecs et al., 2008). Moreover, the analysis seemed to reveal that high pressure influenced the ability to modulate the bucket. Specifically, when participants faced high variability, the bucket was widened more than when they performed the task with low pressure. Probably, in this case, participants should put in action less risky behaviour. Indeed, when pressure or anxiety is high, people try to take fewer risks (Hartley and Phelps, 2012). Furthermore, the decision task analysis partially replicated the results of Study 1 (Chapter 2). In particular, an effect of intelligence on *SE* when the uncertainty was low was found. This happened overall and when participants were exposed to low pressure. However, the differences disappeared when both highly intelligent and normally participants performed the task under high pressure. Additionally, results showed better *Spatial Error* of highly intelligent participants did not lead to a higher *Gain* and better *Gain Error*. Thus the ability to compute the average of the events does not always affect the ability to increase the score. This could be a problem of the task; indeed, as mentioned in both Study 1 and 2 (Chapter 2 and Chapter 3, respectively), our pay-off matrix is linear, and the amount of score increased/decreased two points every two degrees (See also Chapter 5).

These results highlighted a possible effect of intelligence; moreover, we should consider that in Study 1 (Chapter 2) we left 40 minutes to complete the Raven-APM task; (Raven and Court, 1998) thus, even if the high correlation with Raven 20 minutes, (Hamel and Schmittmann, 2006) it is possible that 20 minutes increased the pressure on the task and in our case probably we were not able to discriminate the very highly intelligent participants from the normally intelligent ones. However, it is interesting to notice that highly intelligent participants did not increase the *SE* performance between the two experimental sessions. In contrast, normally intelligent participants were able to increase that performance. This could be due to more cognitive effort in understanding the environment of normally intelligent participants when they were exposed to challenging situations. Indeed, results on RSME (Zijlstra, 1993) revealed that normally intelligent participants increase their mental effort. Thus, these results partially support the *PET* and *ACT* (Eysenck and Calvo, 1992; Eysenck et al., 2007). Another explanation could be that intelligent participants were able to find the pattern without having a motivation boost, while normally intelligent participants when facing high pressure session they should be motivated to perform the task in the best possible way. For what concerned decision task analysis on athletes, no-differences among the three experimental groups emerged. The results contrast with those of study 2 (Chapter 3) where OSG children had a better performance compared to CSG children. In particular, analysis on athletes revealed no-differences among the groups in the four parameters. This could be explained by the age dependence theory (Hötting and Röder, 2013): it is possible that the cognitive benefits of physical activity are more likely to occur in childhood compared to young adulthood. Moreover, the results highlighted that pressure induction did not modify the ability to compute the running mean of the events. However, it seemed that the three experimental groups increased the *Gain* differently on the basis on uncertainty and session. Specifically, open- skill athletes were able to increase the *Gain* when they faced the stressful session but only in Medium σ^*, while the control group when faced the Tight σ^*.

Performance of closed-skill athletes did not improve between the sessions in any of the conditions. Thus, this experiment highlighted that in adulthood to perform well when inferential decisions have to be done; the ability to quickly adapt to mutable situations is less important than high-order cognitive function such as intelligence. Furthermore, the present research confirmed the results on *SD-E* and σ^U: even in this case, participants modulated the bucket differently according to the three uncertainties, but when the uncertainty was low, participants set the bucket larger than necessary.

4.5 Supplemental Information

In the following sections are reported Trial fixed effect for *Spatial Error*, *Gain*, *Gain Error*, *SD-Error* and σ_U for each σ^*.

4.5.1 *Spatial Error*

Below the Trial Analysis on *SE* for each σ^* and for the two experimental sessions.

Table 4.1: *SE* Trial contrast analysis in tight σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	286.9110	40.2758	1523	7.124	<.0001
2 - 4	430.0479	40.2758	1523	10.678	<.0001
2 - 5	477.6096	40.2758	1523	11.858	<.0001
2 - 6	488.7603	40.2758	1523	12.135	<.0001
2 - 7	566.2397	40.2758	1523	14.059	<.0001
2 - 8	562.4521	40.2758	1523	13.965	<.0001
2 - 9	513.8356	40.2758	1523	12.758	<.0001
2 - 10	577.0822	40.2758	1523	14.328	<.0001
2 - 11	584.9589	40.2758	1523	14.524	<.0001
2 - 12	598.9247	40.2758	1523	14.871	<.0001
3 - 4	143.1370	40.2758	1523	3.554	0.0171
3 - 5	190.6986	40.2758	1523	4.735	0.0001
3 - 6	201.8493	40.2758	1523	5.012	<.0001
3 - 7	279.3288	40.2758	1523	6.935	<.0001
3 - 8	275.5411	40.2758	1523	6.841	<.0001
3 - 9	226.9247	40.2758	1523	5.634	<.0001
3 - 10	290.1712	40.2758	1523	7.205	<.0001
3 - 11	298.0479	40.2758	1523	7.400	<.0001
3 - 12	312.0137	40.2758	1523	7.747	<.0001
4 - 5	47.5616	40.2758	1523	1.181	0.9845
4 - 6	58.7123	40.2758	1523	1.458	0.9331
4 - 7	136.1918	40.2758	1523	3.381	0.0305

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Table 4.1 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
4 - 8	132.4041	40.2758	1523	3.287	0.0411
4 - 9	83.7877	40.2758	1523	2.080	0.5917
4 - 10	147.0342	40.2758	1523	3.651	0.0121
4 - 11	154.9110	40.2758	1523	3.846	0.0059
4 - 12	168.8767	40.2758	1523	4.193	0.0015
5 - 6	11.1507	40.2758	1523	0.277	1.0000
5 - 7	88.6301	40.2758	1523	2.201	0.5047
5 - 8	84.8425	40.2758	1523	2.107	0.5727
5 - 9	36.2260	40.2758	1523	0.899	0.9983
5 - 10	99.4726	40.2758	1523	2.470	0.3233
5 - 11	107.3493	40.2758	1523	2.665	0.2168
5 - 12	121.3151	40.2758	1523	3.012	0.0920
6 - 7	77.4795	40.2758	1523	1.924	0.7016
6 - 8	73.6918	40.2758	1523	1.830	0.7624
6 - 9	25.0753	40.2758	1523	0.623	0.9999
6 - 10	88.3219	40.2758	1523	2.193	0.5102
6 - 11	96.1986	40.2758	1523	2.388	0.3746
6 - 12	110.1644	40.2758	1523	2.735	0.1851
7 - 8	-3.7877	40.2758	1523	-0.094	1.0000
7 - 9	-52.4041	40.2758	1523	-1.301	0.9687
7 - 10	10.8425	40.2758	1523	0.269	1.0000
7 - 11	18.7192	40.2758	1523	0.465	1.0000
7 - 12	32.6849	40.2758	1523	0.812	0.9993
8 - 9	-48.6164	40.2758	1523	-1.207	0.9818
8 - 10	14.6301	40.2758	1523	0.363	1.0000
8 - 11	22.5068	40.2758	1523	0.559	1.0000
8 - 12	36.4726	40.2758	1523	0.906	0.9982
9 - 10	63.2466	40.2758	1523	1.570	0.8946
9 - 11	71.1233	40.2758	1523	1.766	0.8001
9 - 12	85.0890	40.2758	1523	2.113	0.5683
10 - 11	7.8767	40.2758	1523	0.196	1.0000
10 - 12	21.8425	40.2758	1523	0.542	1.0000
11 - 12	13.9658	40.2758	1523	0.347	1.0000

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.2: *SE* Trial contrast analysis in medium σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	306.6370	45.7382	1523	6.704	<.0001
2 - 4	400.6027	45.7382	1523	8.759	<.0001
2 - 5	438.3973	45.7382	1523	9.585	<.0001
2 - 6	409.8493	45.7382	1523	8.961	<.0001
2 - 7	367.7877	45.7382	1523	8.041	<.0001
2 - 8	313.0959	45.7382	1523	6.845	<.0001
2 - 9	427.9932	45.7382	1523	9.357	<.0001
2 - 10	372.9315	45.7382	1523	8.154	<.0001
2 - 11	166.9589	45.7382	1523	3.650	0.0122
2 - 12	130.4041	45.7382	1523	2.851	0.1401
3 - 4	93.9658	45.7382	1523	2.054	0.6103
3 - 5	131.7603	45.7382	1523	2.881	0.1301
3 - 6	103.2123	45.7382	1523	2.257	0.4647
3 - 7	61.1507	45.7382	1523	1.337	0.9623
3 - 8	6.4589	45.7382	1523	0.141	1.0000
3 - 9	121.3562	45.7382	1523	2.653	0.2226
3 - 10	66.2945	45.7382	1523	1.449	0.9355
3 - 11	-139.6781	45.7382	1523	-3.054	0.0820
3 - 12	-176.2329	45.7382	1523	-3.853	0.0057
4 - 5	37.7945	45.7382	1523	0.826	0.9992
4 - 6	9.2466	45.7382	1523	0.202	1.0000
4 - 7	-32.8151	45.7382	1523	-0.717	0.9998
4 - 8	-87.5068	45.7382	1523	-1.913	0.7087
4 - 9	27.3904	45.7382	1523	0.599	1.0000
4 - 10	-27.6712	45.7382	1523	-0.605	0.9999
4 - 11	-233.6438	45.7382	1523	-5.108	<.0001
4 - 12	-270.1986	45.7382	1523	-5.907	<.0001
5 - 6	-28.5479	45.7382	1523	-0.624	0.9999
5 - 7	-70.6096	45.7382	1523	-1.544	0.9048
5 - 8	-125.3014	45.7382	1523	-2.740	0.1833
5 - 9	-10.4041	45.7382	1523	-0.227	1.0000
5 - 10	-65.4658	45.7382	1523	-1.431	0.9406
5 - 11	-271.4384	45.7382	1523	-5.935	<.0001
5 - 12	-307.9932	45.7382	1523	-6.734	<.0001
6 - 7	-42.0616	45.7382	1523	-0.920	0.9979

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Table 4.2 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
6 - 8	-96.7534	45.7382	1523	-2.115	0.5663
6 - 9	18.1438	45.7382	1523	0.397	1.0000
6 - 10	-36.9178	45.7382	1523	-0.807	0.9993
6 - 11	-242.8904	45.7382	1523	-5.310	<.0001
6 - 12	-279.4452	45.7382	1523	-6.110	<.0001
7 - 8	-54.6918	45.7382	1523	-1.196	0.9830
7 - 9	60.2055	45.7382	1523	1.316	0.9661
7 - 10	5.1438	45.7382	1523	0.112	1.0000
7 - 11	-200.8288	45.7382	1523	-4.391	0.0006
7 - 12	-237.3836	45.7382	1523	-5.190	<.0001
8 - 9	114.8973	45.7382	1523	2.512	0.2981
8 - 10	59.8356	45.7382	1523	1.308	0.9675
8 - 11	-146.1370	45.7382	1523	-3.195	0.0545
8 - 12	-182.6918	45.7382	1523	-3.994	0.0033
9 - 10	-55.0616	45.7382	1523	-1.204	0.9821
9 - 11	-261.0342	45.7382	1523	-5.707	<.0001
9 - 12	-297.5890	45.7382	1523	-6.506	<.0001
10 - 11	-205.9726	45.7382	1523	-4.503	0.0004
10 - 12	-242.5274	45.7382	1523	-5.303	<.0001
11 - 12	-36.5548	45.7382	1523	-0.799	0.9994

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.3: *SE* Trial contrast analysis in large σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	297.5822	48.3771	1523	6.151	<.0001
2 - 4	350.2123	48.3771	1523	7.239	<.0001
2 - 5	248.4384	48.3771	1523	5.135	<.0001
2 - 6	254.1301	48.3771	1523	5.253	<.0001
2 - 7	93.6233	48.3771	1523	1.935	0.6938
2 - 8	78.7260	48.3771	1523	1.627	0.8707
2 - 9	53.4863	48.3771	1523	1.106	0.9906
2 - 10	53.9589	48.3771	1523	1.115	0.9900

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Table 4.3 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
2 - 11	49.4452	48.3771	1523	1.022	0.9950
2 - 12	93.9247	48.3771	1523	1.942	0.6896
3 - 4	52.6301	48.3771	1523	1.088	0.9917
3 - 5	-49.1438	48.3771	1523	-1.016	0.9952
3 - 6	-43.4521	48.3771	1523	-0.898	0.9983
3 - 7	-203.9589	48.3771	1523	-4.216	0.0013
3 - 8	-218.8562	48.3771	1523	-4.524	0.0003
3 - 9	-244.0959	48.3771	1523	-5.046	<.0001
3 - 10	-243.6233	48.3771	1523	-5.036	<.0001
3 - 11	-248.1370	48.3771	1523	-5.129	<.0001
3 - 12	-203.6575	48.3771	1523	-4.210	0.0014
4 - 5	-101.7740	48.3771	1523	-2.104	0.5747
4 - 6	-96.0822	48.3771	1523	-1.986	0.6588
4 - 7	-256.5890	48.3771	1523	-5.304	<.0001
4 - 8	-271.4863	48.3771	1523	-5.612	<.0001
4 - 9	-296.7260	48.3771	1523	-6.134	<.0001
4 - 10	-296.2534	48.3771	1523	-6.124	<.0001
4 - 11	-300.7671	48.3771	1523	-6.217	<.0001
4 - 12	-256.2877	48.3771	1523	-5.298	<.0001
5 - 6	5.6918	48.3771	1523	0.118	1.0000
5 - 7	-154.8151	48.3771	1523	-3.200	0.0537
5 - 8	-169.7123	48.3771	1523	-3.508	0.0200
5 - 9	-194.9521	48.3771	1523	-4.030	0.0029
5 - 10	-194.4795	48.3771	1523	-4.020	0.0030
5 - 11	-198.9932	48.3771	1523	-4.113	0.0020
5 - 12	-154.5137	48.3771	1523	-3.194	0.0547
6 - 7	-160.5068	48.3771	1523	-3.318	0.0373
6 - 8	-175.4041	48.3771	1523	-3.626	0.0133
6 - 9	-200.6438	48.3771	1523	-4.147	0.0018
6 - 10	-200.1712	48.3771	1523	-4.138	0.0018
6 - 11	-204.6849	48.3771	1523	-4.231	0.0012
6 - 12	-160.2055	48.3771	1523	-3.312	0.0381
7 - 8	-14.8973	48.3771	1523	-0.308	1.0000
7 - 9	-40.1370	48.3771	1523	-0.830	0.9991
7 - 10	-39.6644	48.3771	1523	-0.820	0.9992
7 - 11	-44.1781	48.3771	1523	-0.913	0.9980
7 - 12	0.3014	48.3771	1523	0.006	1.0000

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Table 4.3 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
8 - 9	-25.2397	48.3771	1523	-0.522	1.0000
8 - 10	-24.7671	48.3771	1523	-0.512	1.0000
8 - 11	-29.2808	48.3771	1523	-0.605	0.9999
8 - 12	15.1986	48.3771	1523	0.314	1.0000
9 - 10	0.4726	48.3771	1523	0.010	1.0000
9 - 11	-4.0411	48.3771	1523	-0.084	1.0000
9 - 12	40.4384	48.3771	1523	0.836	0.9991
10 - 11	-4.5137	48.3771	1523	-0.093	1.0000
10 - 12	39.9658	48.3771	1523	0.826	0.9992
11 - 12	44.4795	48.3771	1523	0.919	0.9979

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.4: *SE* Trial contrast analysis in tight σ^* for LPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	133.0548	25.8963	720	5.138	<.0001
2 - 4	190.1507	25.8963	720	7.343	<.0001
2 - 5	206.4247	25.8963	720	7.971	<.0001
2 - 6	184.5616	25.8963	720	7.127	<.0001
2 - 7	256.3151	25.8963	720	9.898	<.0001
2 - 8	276.5616	25.8963	720	10.680	<.0001
2 - 9	260.4110	25.8963	720	10.056	<.0001
2 - 10	248.1096	25.8963	720	9.581	<.0001
2 - 11	276.3288	25.8963	720	10.671	<.0001
2 - 12	297.6712	25.8963	720	11.495	<.0001
3 - 4	57.0959	25.8963	720	2.205	0.5021
3 - 5	73.3699	25.8963	720	2.833	0.1477
3 - 6	51.5068	25.8963	720	1.989	0.6568
3 - 7	123.2603	25.8963	720	4.760	0.0001
3 - 8	143.5068	25.8963	720	5.542	<.0001
3 - 9	127.3562	25.8963	720	4.918	0.0001
3 - 10	115.0548	25.8963	720	4.443	0.0005
3 - 11	143.2740	25.8963	720	5.533	<.0001

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Table 4.4 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 12	164.6164	25.8963	720	6.357	<.0001
4 - 5	16.2740	25.8963	720	0.628	0.9999
4 - 6	-5.5890	25.8963	720	-0.216	1.0000
4 - 7	66.1644	25.8963	720	2.555	0.2748
4 - 8	86.4110	25.8963	720	3.337	0.0359
4 - 9	70.2603	25.8963	720	2.713	0.1959
4 - 10	57.9589	25.8963	720	2.238	0.4783
4 - 11	86.1781	25.8963	720	3.328	0.0369
4 - 12	107.5205	25.8963	720	4.152	0.0018
5 - 6	-21.8630	25.8963	720	-0.844	0.9990
5 - 7	49.8904	25.8963	720	1.927	0.6996
5 - 8	70.1370	25.8963	720	2.708	0.1981
5 - 9	53.9863	25.8963	720	2.085	0.5887
5 - 10	41.6849	25.8963	720	1.610	0.8781
5 - 11	69.9041	25.8963	720	2.699	0.2021
5 - 12	91.2466	25.8963	720	3.524	0.0195
6 - 7	71.7534	25.8963	720	2.771	0.1715
6 - 8	92.0000	25.8963	720	3.553	0.0176
6 - 9	75.8493	25.8963	720	2.929	0.1160
6 - 10	63.5479	25.8963	720	2.454	0.3339
6 - 11	91.7671	25.8963	720	3.544	0.0182
6 - 12	113.1096	25.8963	720	4.368	0.0007
7 - 8	20.2466	25.8963	720	0.782	0.9995
7 - 9	4.0959	25.8963	720	0.158	1.0000
7 - 10	-8.2055	25.8963	720	-0.317	1.0000
7 - 11	20.0137	25.8963	720	0.773	0.9995
7 - 12	41.3562	25.8963	720	1.597	0.8835
8 - 9	-16.1507	25.8963	720	-0.624	0.9999
8 - 10	-28.4521	25.8963	720	-1.099	0.9910
8 - 11	-0.2329	25.8963	720	-0.009	1.0000
8 - 12	21.1096	25.8963	720	0.815	0.9992
9 - 10	-12.3014	25.8963	720	-0.475	1.0000
9 - 11	15.9178	25.8963	720	0.615	0.9999
9 - 12	37.2603	25.8963	720	1.439	0.9383
10 - 11	28.2192	25.8963	720	1.090	0.9916
10 - 12	49.5616	25.8963	720	1.914	0.7081
11 - 12	21.3425	25.8963	720	0.824	0.9992

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Table 4.4 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
Note: contrasts are still on the rank scale					
Degrees-of-freedom method: kenward-roger					
P value adjustment: tukey method for comparing a family of 11 estimates					

Table 4.5: *SE* Trial contrast analysis in tight σ^* for HPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	155.0959	26.4651	720	5.860	<.0001
2 - 4	240.5616	26.4651	720	9.090	<.0001
2 - 5	273.2740	26.4651	720	10.326	<.0001
2 - 6	307.1507	26.4651	720	11.606	<.0001
2 - 7	311.4658	26.4651	720	11.769	<.0001
2 - 8	287.2055	26.4651	720	10.852	<.0001
2 - 9	253.5342	26.4651	720	9.580	<.0001
2 - 10	329.7945	26.4651	720	12.462	<.0001
2 - 11	308.6712	26.4651	720	11.663	<.0001
2 - 12	301.3288	26.4651	720	11.386	<.0001
3 - 4	85.4658	26.4651	720	3.229	0.0500
3 - 5	118.1781	26.4651	720	4.465	0.0005
3 - 6	152.0548	26.4651	720	5.745	<.0001
3 - 7	156.3699	26.4651	720	5.909	<.0001
3 - 8	132.1096	26.4651	720	4.992	<.0001
3 - 9	98.4384	26.4651	720	3.720	0.0098
3 - 10	174.6986	26.4651	720	6.601	<.0001
3 - 11	153.5753	26.4651	720	5.803	<.0001
3 - 12	146.2329	26.4651	720	5.526	<.0001
4 - 5	32.7123	26.4651	720	1.236	0.9782
4 - 6	66.5890	26.4651	720	2.516	0.2968
4 - 7	70.9041	26.4651	720	2.679	0.2114
4 - 8	46.6438	26.4651	720	1.762	0.8018
4 - 9	12.9726	26.4651	720	0.490	1.0000
4 - 10	89.2329	26.4651	720	3.372	0.0321
4 - 11	68.1096	26.4651	720	2.574	0.2646
4 - 12	60.7671	26.4651	720	2.296	0.4376
5 - 6	33.8767	26.4651	720	1.280	0.9720

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Table 4.5 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
5 - 7	38.1918	26.4651	720	1.443	0.9371
5 - 8	13.9315	26.4651	720	0.526	1.0000
5 - 9	-19.7397	26.4651	720	-0.746	0.9997
5 - 10	56.5205	26.4651	720	2.136	0.5519
5 - 11	35.3973	26.4651	720	1.338	0.9620
5 - 12	28.0548	26.4651	720	1.060	0.9932
6 - 7	4.3151	26.4651	720	0.163	1.0000
6 - 8	-19.9452	26.4651	720	-0.754	0.9996
6 - 9	-53.6164	26.4651	720	-2.026	0.6308
6 - 10	22.6438	26.4651	720	0.856	0.9989
6 - 11	1.5205	26.4651	720	0.057	1.0000
6 - 12	-5.8219	26.4651	720	-0.220	1.0000
7 - 8	-24.2603	26.4651	720	-0.917	0.9979
7 - 9	-57.9315	26.4651	720	-2.189	0.5134
7 - 10	18.3288	26.4651	720	0.693	0.9998
7 - 11	-2.7945	26.4651	720	-0.106	1.0000
7 - 12	-10.1370	26.4651	720	-0.383	1.0000
8 - 9	-33.6712	26.4651	720	-1.272	0.9732
8 - 10	42.5890	26.4651	720	1.609	0.8783
8 - 11	21.4658	26.4651	720	0.811	0.9993
8 - 12	14.1233	26.4651	720	0.534	1.0000
9 - 10	76.2603	26.4651	720	2.882	0.1310
9 - 11	55.1370	26.4651	720	2.083	0.5897
9 - 12	47.7945	26.4651	720	1.806	0.7765
10 - 11	-21.1233	26.4651	720	-0.798	0.9994
10 - 12	-28.4658	26.4651	720	-1.076	0.9924
11 - 12	-7.3425	26.4651	720	-0.277	1.0000

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.6: *SE* Trial contrast analysis in Medium σ^* for LPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	179.0822	31.2096	720	5.738	<.0001

Continued on next page

Table 4.6 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
2 - 4	219.6575	31.2096	720	7.038	<.0001
2 - 5	243.9452	31.2096	720	7.816	<.0001
2 - 6	190.5616	31.2096	720	6.106	<.0001
2 - 7	198.0685	31.2096	720	6.346	<.0001
2 - 8	169.4247	31.2096	720	5.429	<.0001
2 - 9	199.0959	31.2096	720	6.379	<.0001
2 - 10	181.4795	31.2096	720	5.815	<.0001
2 - 11	73.8493	31.2096	720	2.366	0.3901
2 - 12	78.4658	31.2096	720	2.514	0.2979
3 - 4	40.5753	31.2096	720	1.300	0.9688
3 - 5	64.8630	31.2096	720	2.078	0.5933
3 - 6	11.4795	31.2096	720	0.368	1.0000
3 - 7	18.9863	31.2096	720	0.608	0.9999
3 - 8	-9.6575	31.2096	720	-0.309	1.0000
3 - 9	20.0137	31.2096	720	0.641	0.9999
3 - 10	2.3973	31.2096	720	0.077	1.0000
3 - 11	-105.2329	31.2096	720	-3.372	0.0321
3 - 12	-100.6164	31.2096	720	-3.224	0.0508
4 - 5	24.2877	31.2096	720	0.778	0.9995
4 - 6	-29.0959	31.2096	720	-0.932	0.9976
4 - 7	-21.5890	31.2096	720	-0.692	0.9998
4 - 8	-50.2329	31.2096	720	-1.610	0.8782
4 - 9	-20.5616	31.2096	720	-0.659	0.9999
4 - 10	-38.1781	31.2096	720	-1.223	0.9798
4 - 11	-145.8082	31.2096	720	-4.672	0.0002
4 - 12	-141.1918	31.2096	720	-4.524	0.0004
5 - 6	-53.3836	31.2096	720	-1.710	0.8301
5 - 7	-45.8767	31.2096	720	-1.470	0.9293
5 - 8	-74.5205	31.2096	720	-2.388	0.3759
5 - 9	-44.8493	31.2096	720	-1.437	0.9388
5 - 10	-62.4658	31.2096	720	-2.001	0.6480
5 - 11	-170.0959	31.2096	720	-5.450	<.0001
5 - 12	-165.4795	31.2096	720	-5.302	<.0001
6 - 7	7.5068	31.2096	720	0.241	1.0000
6 - 8	-21.1370	31.2096	720	-0.677	0.9999
6 - 9	8.5342	31.2096	720	0.273	1.0000
6 - 10	-9.0822	31.2096	720	-0.291	1.0000

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Table 4.6 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
6 - 11	-116.7123	31.2096	720	-3.740	0.0091
6 - 12	-112.0959	31.2096	720	-3.592	0.0154
7 - 8	-28.6438	31.2096	720	-0.918	0.9979
7 - 9	1.0274	31.2096	720	0.033	1.0000
7 - 10	-16.5890	31.2096	720	-0.532	1.0000
7 - 11	-124.2192	31.2096	720	-3.980	0.0036
7 - 12	-119.6027	31.2096	720	-3.832	0.0064
8 - 9	29.6712	31.2096	720	0.951	0.9972
8 - 10	12.0548	31.2096	720	0.386	1.0000
8 - 11	-95.5753	31.2096	720	-3.062	0.0811
8 - 12	-90.9589	31.2096	720	-2.914	0.1204
9 - 10	-17.6164	31.2096	720	-0.564	1.0000
9 - 11	-125.2466	31.2096	720	-4.013	0.0032
9 - 12	-120.6301	31.2096	720	-3.865	0.0057
10 - 11	-107.6301	31.2096	720	-3.449	0.0250
10 - 12	-103.0137	31.2096	720	-3.301	0.0402
11 - 12	4.6164	31.2096	720	0.148	1.0000

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.7: *SE* Trial contrast analysis in Medium σ^* for HPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	126.5479	29.9071	720	4.231	0.0013
2 - 4	180.0685	29.9071	720	6.021	<.0001
2 - 5	194.6986	29.9071	720	6.510	<.0001
2 - 6	220.4247	29.9071	720	7.370	<.0001
2 - 7	170.5616	29.9071	720	5.703	<.0001
2 - 8	144.7534	29.9071	720	4.840	0.0001
2 - 9	228.7397	29.9071	720	7.648	<.0001
2 - 10	192.0822	29.9071	720	6.423	<.0001
2 - 11	96.6027	29.9071	720	3.230	0.0499
2 - 12	53.1781	29.9071	720	1.778	0.7929
3 - 4	53.5205	29.9071	720	1.790	0.7862

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Table 4.7 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 5	68.1507	29.9071	720	2.279	0.4497
3 - 6	93.8767	29.9071	720	3.139	0.0652
3 - 7	44.0137	29.9071	720	1.472	0.9287
3 - 8	18.2055	29.9071	720	0.609	0.9999
3 - 9	102.1918	29.9071	720	3.417	0.0277
3 - 10	65.5342	29.9071	720	2.191	0.5118
3 - 11	-29.9452	29.9071	720	-1.001	0.9957
3 - 12	-73.3699	29.9071	720	-2.453	0.3343
4 - 5	14.6301	29.9071	720	0.489	1.0000
4 - 6	40.3562	29.9071	720	1.349	0.9596
4 - 7	-9.5068	29.9071	720	-0.318	1.0000
4 - 8	-35.3151	29.9071	720	-1.181	0.9844
4 - 9	48.6712	29.9071	720	1.627	0.8703
4 - 10	12.0137	29.9071	720	0.402	1.0000
4 - 11	-83.4658	29.9071	720	-2.791	0.1636
4 - 12	-126.8904	29.9071	720	-4.243	0.0013
5 - 6	25.7260	29.9071	720	0.860	0.9988
5 - 7	-24.1370	29.9071	720	-0.807	0.9993
5 - 8	-49.9452	29.9071	720	-1.670	0.8504
5 - 9	34.0411	29.9071	720	1.138	0.9882
5 - 10	-2.6164	29.9071	720	-0.087	1.0000
5 - 11	-98.0959	29.9071	720	-3.280	0.0428
5 - 12	-141.5205	29.9071	720	-4.732	0.0001
6 - 7	-49.8630	29.9071	720	-1.667	0.8518
6 - 8	-75.6712	29.9071	720	-2.530	0.2887
6 - 9	8.3151	29.9071	720	0.278	1.0000
6 - 10	-28.3425	29.9071	720	-0.948	0.9973
6 - 11	-123.8219	29.9071	720	-4.140	0.0019
6 - 12	-167.2466	29.9071	720	-5.592	<.0001
7 - 8	-25.8082	29.9071	720	-0.863	0.9988
7 - 9	58.1781	29.9071	720	1.945	0.6870
7 - 10	21.5205	29.9071	720	0.720	0.9998
7 - 11	-73.9589	29.9071	720	-2.473	0.3223
7 - 12	-117.3836	29.9071	720	-3.925	0.0045
8 - 9	83.9863	29.9071	720	2.808	0.1569
8 - 10	47.3288	29.9071	720	1.583	0.8894
8 - 11	-48.1507	29.9071	720	-1.610	0.8780

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Table 4.7 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
8 - 12	-91.5753	29.9071	720	-3.062	0.0812
9 - 10	-36.6575	29.9071	720	-1.226	0.9795
9 - 11	-132.1370	29.9071	720	-4.418	0.0006
9 - 12	-175.5616	29.9071	720	-5.870	<.0001
10 - 11	-95.4795	29.9071	720	-3.193	0.0558
10 - 12	-138.9041	29.9071	720	-4.645	0.0002
11 - 12	-43.4247	29.9071	720	-1.452	0.9346

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.8: *SE* Trial contrast analysis in Large σ^* for LPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	138.7260	32.4302	720	4.278	0.0011
2 - 4	200.5479	32.4302	720	6.184	<.0001
2 - 5	126.3014	32.4302	720	3.895	0.0051
2 - 6	122.4110	32.4302	720	3.775	0.0080
2 - 7	44.4795	32.4302	720	1.372	0.9549
2 - 8	10.2877	32.4302	720	0.317	1.0000
2 - 9	3.7534	32.4302	720	0.116	1.0000
2 - 10	18.7260	32.4302	720	0.577	1.0000
2 - 11	36.6986	32.4302	720	1.132	0.9887
2 - 12	60.9863	32.4302	720	1.881	0.7300
3 - 4	61.8219	32.4302	720	1.906	0.7131
3 - 5	-12.4247	32.4302	720	-0.383	1.0000
3 - 6	-16.3151	32.4302	720	-0.503	1.0000
3 - 7	-94.2466	32.4302	720	-2.906	0.1230
3 - 8	-128.4384	32.4302	720	-3.960	0.0039
3 - 9	-134.9726	32.4302	720	-4.162	0.0018
3 - 10	-120.0000	32.4302	720	-3.700	0.0105
3 - 11	-102.0274	32.4302	720	-3.146	0.0639
3 - 12	-77.7397	32.4302	720	-2.397	0.3698
4 - 5	-74.2466	32.4302	720	-2.289	0.4423
4 - 6	-78.1370	32.4302	720	-2.409	0.3619

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Table 4.8 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
4 - 7	-156.0685	32.4302	720	-4.812	0.0001
4 - 8	-190.2603	32.4302	720	-5.867	<.0001
4 - 9	-196.7945	32.4302	720	-6.068	<.0001
4 - 10	-181.8219	32.4302	720	-5.607	<.0001
4 - 11	-163.8493	32.4302	720	-5.052	<.0001
4 - 12	-139.5616	32.4302	720	-4.303	0.0010
5 - 6	-3.8904	32.4302	720	-0.120	1.0000
5 - 7	-81.8219	32.4302	720	-2.523	0.2928
5 - 8	-116.0137	32.4302	720	-3.577	0.0162
5 - 9	-122.5479	32.4302	720	-3.779	0.0079
5 - 10	-107.5753	32.4302	720	-3.317	0.0382
5 - 11	-89.6027	32.4302	720	-2.763	0.1747
5 - 12	-65.3151	32.4302	720	-2.014	0.6392
6 - 7	-77.9315	32.4302	720	-2.403	0.3660
6 - 8	-112.1233	32.4302	720	-3.457	0.0243
6 - 9	-118.6575	32.4302	720	-3.659	0.0122
6 - 10	-103.6849	32.4302	720	-3.197	0.0550
6 - 11	-85.7123	32.4302	720	-2.643	0.2288
6 - 12	-61.4247	32.4302	720	-1.894	0.7212
7 - 8	-34.1918	32.4302	720	-1.054	0.9935
7 - 9	-40.7260	32.4302	720	-1.256	0.9756
7 - 10	-25.7534	32.4302	720	-0.794	0.9994
7 - 11	-7.7808	32.4302	720	-0.240	1.0000
7 - 12	16.5068	32.4302	720	0.509	1.0000
8 - 9	-6.5342	32.4302	720	-0.201	1.0000
8 - 10	8.4384	32.4302	720	0.260	1.0000
8 - 11	26.4110	32.4302	720	0.814	0.9993
8 - 12	50.6986	32.4302	720	1.563	0.8971
9 - 10	14.9726	32.4302	720	0.462	1.0000
9 - 11	32.9452	32.4302	720	1.016	0.9952
9 - 12	57.2329	32.4302	720	1.765	0.8005
10 - 11	17.9726	32.4302	720	0.554	1.0000
10 - 12	42.2603	32.4302	720	1.303	0.9682
11 - 12	24.2877	32.4302	720	0.749	0.9996

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.9: *SE* Trial contrast analysis in Large σ^* for HPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	157.1781	33.5320	720	4.687	0.0002
2 - 4	147.3288	33.5320	720	4.394	0.0007
2 - 5	121.0685	33.5320	720	3.611	0.0144
2 - 6	130.5753	33.5320	720	3.894	0.0051
2 - 7	48.9726	33.5320	720	1.460	0.9321
2 - 8	68.5616	33.5320	720	2.045	0.6174
2 - 9	48.9315	33.5320	720	1.459	0.9325
2 - 10	34.7260	33.5320	720	1.036	0.9944
2 - 11	11.7260	33.5320	720	0.350	1.0000
2 - 12	32.2740	33.5320	720	0.962	0.9969
3 - 4	-9.8493	33.5320	720	-0.294	1.0000
3 - 5	-36.1096	33.5320	720	-1.077	0.9923
3 - 6	-26.6027	33.5320	720	-0.793	0.9994
3 - 7	-108.2055	33.5320	720	-3.227	0.0503
3 - 8	-88.6164	33.5320	720	-2.643	0.2289
3 - 9	-108.2466	33.5320	720	-3.228	0.0501
3 - 10	-122.4521	33.5320	720	-3.652	0.0125
3 - 11	-145.4521	33.5320	720	-4.338	0.0008
3 - 12	-124.9041	33.5320	720	-3.725	0.0096
4 - 5	-26.2603	33.5320	720	-0.783	0.9995
4 - 6	-16.7534	33.5320	720	-0.500	1.0000
4 - 7	-98.3562	33.5320	720	-2.933	0.1147
4 - 8	-78.7671	33.5320	720	-2.349	0.4016
4 - 9	-98.3973	33.5320	720	-2.934	0.1144
4 - 10	-112.6027	33.5320	720	-3.358	0.0335
4 - 11	-135.6027	33.5320	720	-4.044	0.0028
4 - 12	-115.0548	33.5320	720	-3.431	0.0265
5 - 6	9.5068	33.5320	720	0.284	1.0000
5 - 7	-72.0959	33.5320	720	-2.150	0.5415
5 - 8	-52.5068	33.5320	720	-1.566	0.8961
5 - 9	-72.1370	33.5320	720	-2.151	0.5406
5 - 10	-86.3425	33.5320	720	-2.575	0.2639
5 - 11	-109.3425	33.5320	720	-3.261	0.0454
5 - 12	-88.7945	33.5320	720	-2.648	0.2263
6 - 7	-81.6027	33.5320	720	-2.434	0.3466

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Table 4.9 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
6 - 8	-62.0137	33.5320	720	-1.849	0.7499
6 - 9	-81.6438	33.5320	720	-2.435	0.3458
6 - 10	-95.8493	33.5320	720	-2.858	0.1388
6 - 11	-118.8493	33.5320	720	-3.544	0.0181
6 - 12	-98.3014	33.5320	720	-2.932	0.1152
7 - 8	19.5890	33.5320	720	0.584	1.0000
7 - 9	-0.0411	33.5320	720	-0.001	1.0000
7 - 10	-14.2466	33.5320	720	-0.425	1.0000
7 - 11	-37.2466	33.5320	720	-1.111	0.9902
7 - 12	-16.6986	33.5320	720	-0.498	1.0000
8 - 9	-19.6301	33.5320	720	-0.585	1.0000
8 - 10	-33.8356	33.5320	720	-1.009	0.9954
8 - 11	-56.8356	33.5320	720	-1.695	0.8380
8 - 12	-36.2877	33.5320	720	-1.082	0.9920
9 - 10	-14.2055	33.5320	720	-0.424	1.0000
9 - 11	-37.2055	33.5320	720	-1.110	0.9903
9 - 12	-16.6575	33.5320	720	-0.497	1.0000
10 - 11	-23.0000	33.5320	720	-0.686	0.9998
10 - 12	-2.4521	33.5320	720	-0.073	1.0000
11 - 12	20.5479	33.5320	720	0.613	0.9999

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

4.5.2 *Gain*

Below the Trial Analysis on *Gain* for each σ^* and for each experimental session.

Table 4.10: *Gain Error* Trial contrast analysis in Tight σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-212.7089	47.4255	1523	-4.485	0.0004
2 - 4	-417.6678	47.4255	1523	-8.807	<.0001
2 - 5	-416.5479	47.4255	1523	-8.783	<.0001
2 - 6	-363.4555	47.4255	1523	-7.664	<.0001
2 - 7	-519.0479	47.4255	1523	-10.944	<.0001
2 - 8	-367.9007	47.4255	1523	-7.757	<.0001
2 - 9	-329.3596	47.4255	1523	-6.945	<.0001
2 - 10	-436.4589	47.4255	1523	-9.203	<.0001
2 - 11	-367.6541	47.4255	1523	-7.752	<.0001
2 - 12	-390.9452	47.4255	1523	-8.243	<.0001
3 - 4	-204.9589	47.4255	1523	-4.322	0.0008
3 - 5	-203.8390	47.4255	1523	-4.298	0.0009
3 - 6	-150.7466	47.4255	1523	-3.179	0.0572
3 - 7	-306.3390	47.4255	1523	-6.459	<.0001
3 - 8	-155.1918	47.4255	1523	-3.272	0.0431
3 - 9	-116.6507	47.4255	1523	-2.460	0.3295
3 - 10	-223.7500	47.4255	1523	-4.718	0.0001
3 - 11	-154.9452	47.4255	1523	-3.267	0.0438
3 - 12	-178.2363	47.4255	1523	-3.758	0.0082
4 - 5	1.1199	47.4255	1523	0.024	1.0000
4 - 6	54.2123	47.4255	1523	1.143	0.9879
4 - 7	-101.3801	47.4255	1523	-2.138	0.5502
4 - 8	49.7671	47.4255	1523	1.049	0.9938
4 - 9	88.3082	47.4255	1523	1.862	0.7421
4 - 10	-18.7911	47.4255	1523	-0.396	1.0000
4 - 11	50.0137	47.4255	1523	1.055	0.9935
4 - 12	26.7226	47.4255	1523	0.563	1.0000
5 - 6	53.0925	47.4255	1523	1.119	0.9897
5 - 7	-102.5000	47.4255	1523	-2.161	0.5331
5 - 8	48.6473	47.4255	1523	1.026	0.9948
5 - 9	87.1884	47.4255	1523	1.838	0.7569
5 - 10	-19.9110	47.4255	1523	-0.420	1.0000
5 - 11	48.8938	47.4255	1523	1.031	0.9946
5 - 12	25.6027	47.4255	1523	0.540	1.0000
6 - 7	-155.5925	47.4255	1523	-3.281	0.0419
6 - 8	-4.4452	47.4255	1523	-0.094	1.0000

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Table 4.10 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
6 - 9	34.0959	47.4255	1523	0.719	0.9998
6 - 10	-73.0034	47.4255	1523	-1.539	0.9064
6 - 11	-4.1986	47.4255	1523	-0.089	1.0000
6 - 12	-27.4897	47.4255	1523	-0.580	1.0000
7 - 8	151.1473	47.4255	1523	3.187	0.0558
7 - 9	189.6884	47.4255	1523	4.000	0.0032
7 - 10	82.5890	47.4255	1523	1.741	0.8138
7 - 11	151.3938	47.4255	1523	3.192	0.0549
7 - 12	128.1027	47.4255	1523	2.701	0.2001
8 - 9	38.5411	47.4255	1523	0.813	0.9993
8 - 10	-68.5582	47.4255	1523	-1.446	0.9366
8 - 11	0.2466	47.4255	1523	0.005	1.0000
8 - 12	-23.0445	47.4255	1523	-0.486	1.0000
9 - 10	-107.0993	47.4255	1523	-2.258	0.4635
9 - 11	-38.2945	47.4255	1523	-0.807	0.9993
9 - 12	-61.5856	47.4255	1523	-1.299	0.9692
10 - 11	68.8048	47.4255	1523	1.451	0.9352
10 - 12	45.5137	47.4255	1523	0.960	0.9970
11 - 12	-23.2911	47.4255	1523	-0.491	1.0000

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 10 estimates

Table 4.11: *Gain* Trial contrast analysis in Medium σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-128.5548	51.2221	1523	-2.510	0.2994
2 - 4	-195.2637	51.2221	1523	-3.812	0.0067
2 - 5	-349.8664	51.2221	1523	-6.830	<.0001
2 - 6	-298.3733	51.2221	1523	-5.825	<.0001
2 - 7	-268.8219	51.2221	1523	-5.248	<.0001
2 - 8	-323.6404	51.2221	1523	-6.318	<.0001
2 - 9	-330.0479	51.2221	1523	-6.443	<.0001
2 - 10	-57.2260	51.2221	1523	-1.117	0.9899
2 - 11	-214.6507	51.2221	1523	-4.191	0.0015

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Table 4.11 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
2 - 12	-165.4418	51.2221	1523	-3.230	0.0491
3 - 4	-66.7089	51.2221	1523	-1.302	0.9685
3 - 5	-221.3116	51.2221	1523	-4.321	0.0008
3 - 6	-169.8185	51.2221	1523	-3.315	0.0376
3 - 7	-140.2671	51.2221	1523	-2.738	0.1838
3 - 8	-195.0856	51.2221	1523	-3.809	0.0068
3 - 9	-201.4932	51.2221	1523	-3.934	0.0042
3 - 10	71.3288	51.2221	1523	1.393	0.9503
3 - 11	-86.0959	51.2221	1523	-1.681	0.8454
3 - 12	-36.8870	51.2221	1523	-0.720	0.9998
4 - 5	-154.6027	51.2221	1523	-3.018	0.0905
4 - 6	-103.1096	51.2221	1523	-2.013	0.6399
4 - 7	-73.5582	51.2221	1523	-1.436	0.9393
4 - 8	-128.3767	51.2221	1523	-2.506	0.3015
4 - 9	-134.7842	51.2221	1523	-2.631	0.2334
4 - 10	138.0377	51.2221	1523	2.695	0.2030
4 - 11	-19.3870	51.2221	1523	-0.378	1.0000
4 - 12	29.8219	51.2221	1523	0.582	1.0000
5 - 6	51.4932	51.2221	1523	1.005	0.9956
5 - 7	81.0445	51.2221	1523	1.582	0.8899
5 - 8	26.2260	51.2221	1523	0.512	1.0000
5 - 9	19.8185	51.2221	1523	0.387	1.0000
5 - 10	292.6404	51.2221	1523	5.713	<.0001
5 - 11	135.2158	51.2221	1523	2.640	0.2292
5 - 12	184.4247	51.2221	1523	3.600	0.0145
6 - 7	29.5514	51.2221	1523	0.577	1.0000
6 - 8	-25.2671	51.2221	1523	-0.493	1.0000
6 - 9	-31.6747	51.2221	1523	-0.618	0.9999
6 - 10	241.1473	51.2221	1523	4.708	0.0001
6 - 11	83.7226	51.2221	1523	1.635	0.8674
6 - 12	132.9315	51.2221	1523	2.595	0.2520
7 - 8	-54.8185	51.2221	1523	-1.070	0.9927
7 - 9	-61.2260	51.2221	1523	-1.195	0.9831
7 - 10	211.5959	51.2221	1523	4.131	0.0019
7 - 11	54.1712	51.2221	1523	1.058	0.9934
7 - 12	103.3801	51.2221	1523	2.018	0.6362
8 - 9	-6.4075	51.2221	1523	-0.125	1.0000

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Table 4.11 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
8 - 10	266.4144	51.2221	1523	5.201	<.0001
8 - 11	108.9897	51.2221	1523	2.128	0.5573
8 - 12	158.1986	51.2221	1523	3.088	0.0744
9 - 10	272.8219	51.2221	1523	5.326	<.0001
9 - 11	115.3973	51.2221	1523	2.253	0.4673
9 - 12	164.6062	51.2221	1523	3.214	0.0515
10 - 11	-157.4247	51.2221	1523	-3.073	0.0776
10 - 12	-108.2158	51.2221	1523	-2.113	0.5683
11 - 12	49.2089	51.2221	1523	0.961	0.9970

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 4.12: *Gain* Trial contrast analysis in Large σ^*

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-183.9247	51.4329	1523	-3.576	0.0158
2 - 4	-153.0651	51.4329	1523	-2.976	0.1015
2 - 5	-150.3973	51.4329	1523	-2.924	0.1163
2 - 6	-83.0274	51.4329	1523	-1.614	0.8764
2 - 7	26.7945	51.4329	1523	0.521	1.0000
2 - 8	-9.4486	51.4329	1523	-0.184	1.0000
2 - 9	-173.7842	51.4329	1523	-3.379	0.0307
2 - 10	17.3151	51.4329	1523	0.337	1.0000
2 - 11	-81.6610	51.4329	1523	-1.588	0.8876
2 - 12	-246.3425	51.4329	1523	-4.790	0.0001
3 - 4	30.8596	51.4329	1523	0.600	1.0000
3 - 5	33.5274	51.4329	1523	0.652	0.9999
3 - 6	100.8973	51.4329	1523	1.962	0.6757
3 - 7	210.7192	51.4329	1523	4.097	0.0022
3 - 8	174.4760	51.4329	1523	3.392	0.0294
3 - 9	10.1404	51.4329	1523	0.197	1.0000
3 - 10	201.2397	51.4329	1523	3.913	0.0045
3 - 11	102.2637	51.4329	1523	1.988	0.6573
3 - 12	-62.4178	51.4329	1523	-1.214	0.9811

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Table 4.12 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
4 - 5	2.6678	51.4329	1523	0.052	1.0000
4 - 6	70.0377	51.4329	1523	1.362	0.9572
4 - 7	179.8596	51.4329	1523	3.497	0.0208
4 - 8	143.6164	51.4329	1523	2.792	0.1618
4 - 9	-20.7192	51.4329	1523	-0.403	1.0000
4 - 10	170.3801	51.4329	1523	3.313	0.0380
4 - 11	71.4041	51.4329	1523	1.388	0.9513
4 - 12	-93.2774	51.4329	1523	-1.814	0.7722
5 - 6	67.3699	51.4329	1523	1.310	0.9673
5 - 7	177.1918	51.4329	1523	3.445	0.0247
5 - 8	140.9486	51.4329	1523	2.740	0.1829
5 - 9	-23.3870	51.4329	1523	-0.455	1.0000
5 - 10	167.7123	51.4329	1523	3.261	0.0446
5 - 11	68.7363	51.4329	1523	1.336	0.9624
5 - 12	-95.9452	51.4329	1523	-1.865	0.7399
6 - 7	109.8219	51.4329	1523	2.135	0.5519
6 - 8	73.5788	51.4329	1523	1.431	0.9408
6 - 9	-90.7568	51.4329	1523	-1.765	0.8009
6 - 10	100.3425	51.4329	1523	1.951	0.6832
6 - 11	1.3664	51.4329	1523	0.027	1.0000
6 - 12	-163.3151	51.4329	1523	-3.175	0.0578
7 - 8	-36.2432	51.4329	1523	-0.705	0.9998
7 - 9	-200.5788	51.4329	1523	-3.900	0.0048
7 - 10	-9.4795	51.4329	1523	-0.184	1.0000
7 - 11	-108.4555	51.4329	1523	-2.109	0.5712
7 - 12	-273.1370	51.4329	1523	-5.311	<.0001
8 - 9	-164.3356	51.4329	1523	-3.195	0.0545
8 - 10	26.7637	51.4329	1523	0.520	1.0000
8 - 11	-72.2123	51.4329	1523	-1.404	0.9476
8 - 12	-236.8938	51.4329	1523	-4.606	0.0002
9 - 10	191.0993	51.4329	1523	3.716	0.0096
9 - 11	92.1233	51.4329	1523	1.791	0.7856
9 - 12	-72.5582	51.4329	1523	-1.411	0.9459
10 - 11	-98.9760	51.4329	1523	-1.924	0.7012
10 - 12	-263.6575	51.4329	1523	-5.126	<.0001
11 - 12	-164.6815	51.4329	1523	-3.202	0.0534

Note: contrasts are still on the rank scale

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Table 4.12 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
Degrees-of-freedom method: kenward-roger					
P value adjustment: tukey method for comparing a family of 10 estimates					

Table 4.13: *Gain* Trial contrast analysis in Tight σ^* for LPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-90.3699	32.9879	720	-2.739	0.1845
2 - 4	-184.8014	32.9879	720	-5.602	<.0001
2 - 5	-168.0274	32.9879	720	-5.094	<.0001
2 - 6	-157.5205	32.9879	720	-4.775	0.0001
2 - 7	-232.5411	32.9879	720	-7.049	<.0001
2 - 8	-141.4726	32.9879	720	-4.289	0.0010
2 - 9	-149.6712	32.9879	720	-4.537	0.0003
2 - 10	-165.7466	32.9879	720	-5.024	<.0001
2 - 11	-164.0822	32.9879	720	-4.974	<.0001
2 - 12	-191.5479	32.9879	720	-5.807	<.0001
3 - 4	-94.4315	32.9879	720	-2.863	0.1373
3 - 5	-77.6575	32.9879	720	-2.354	0.3981
3 - 6	-67.1507	32.9879	720	-2.036	0.6239
3 - 7	-142.1712	32.9879	720	-4.310	0.0009
3 - 8	-51.1027	32.9879	720	-1.549	0.9025
3 - 9	-59.3014	32.9879	720	-1.798	0.7815
3 - 10	-75.3767	32.9879	720	-2.285	0.4454
3 - 11	-73.7123	32.9879	720	-2.235	0.4809
3 - 12	-101.1781	32.9879	720	-3.067	0.0800
4 - 5	16.7740	32.9879	720	0.508	1.0000
4 - 6	27.2808	32.9879	720	0.827	0.9991
4 - 7	-47.7397	32.9879	720	-1.447	0.9359
4 - 8	43.3288	32.9879	720	1.313	0.9664
4 - 9	35.1301	32.9879	720	1.065	0.9930
4 - 10	19.0548	32.9879	720	0.578	1.0000
4 - 11	20.7192	32.9879	720	0.628	0.9999
4 - 12	-6.7466	32.9879	720	-0.205	1.0000
5 - 6	10.5068	32.9879	720	0.319	1.0000
5 - 7	-64.5137	32.9879	720	-1.956	0.6799

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Table 4.13 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
5 - 8	26.5548	32.9879	720	0.805	0.9993
5 - 9	18.3562	32.9879	720	0.556	1.0000
5 - 10	2.2808	32.9879	720	0.069	1.0000
5 - 11	3.9452	32.9879	720	0.120	1.0000
5 - 12	-23.5205	32.9879	720	-0.713	0.9998
6 - 7	-75.0205	32.9879	720	-2.274	0.4529
6 - 8	16.0479	32.9879	720	0.486	1.0000
6 - 9	7.8493	32.9879	720	0.238	1.0000
6 - 10	-8.2260	32.9879	720	-0.249	1.0000
6 - 11	-6.5616	32.9879	720	-0.199	1.0000
6 - 12	-34.0274	32.9879	720	-1.032	0.9945
7 - 8	91.0685	32.9879	720	2.761	0.1757
7 - 9	82.8699	32.9879	720	2.512	0.2991
7 - 10	66.7945	32.9879	720	2.025	0.6316
7 - 11	68.4589	32.9879	720	2.075	0.5955
7 - 12	40.9932	32.9879	720	1.243	0.9773
8 - 9	-8.1986	32.9879	720	-0.249	1.0000
8 - 10	-24.2740	32.9879	720	-0.736	0.9997
8 - 11	-22.6096	32.9879	720	-0.685	0.9998
8 - 12	-50.0753	32.9879	720	-1.518	0.9137
9 - 10	-16.0753	32.9879	720	-0.487	1.0000
9 - 11	-14.4110	32.9879	720	-0.437	1.0000
9 - 12	-41.8767	32.9879	720	-1.269	0.9736
10 - 11	1.6644	32.9879	720	0.050	1.0000
10 - 12	-25.8014	32.9879	720	-0.782	0.9995
11 - 12	-27.4658	32.9879	720	-0.833	0.9991

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.14: *Gain* Trial contrast analysis in Tight σ^* for HPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-123.7808	33.0595	720	-3.744	0.0089
2 - 4	-234.0411	33.0595	720	-7.079	<.0001

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Table 4.14 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
2 - 5	-251.8630	33.0595	720	-7.618	<.0001
2 - 6	-209.2534	33.0595	720	-6.330	<.0001
2 - 7	-290.3973	33.0595	720	-8.784	<.0001
2 - 8	-227.0685	33.0595	720	-6.868	<.0001
2 - 9	-181.6918	33.0595	720	-5.496	<.0001
2 - 10	-272.3014	33.0595	720	-8.237	<.0001
2 - 11	-203.3014	33.0595	720	-6.150	<.0001
2 - 12	-202.7603	33.0595	720	-6.133	<.0001
3 - 4	-110.2603	33.0595	720	-3.335	0.0360
3 - 5	-128.0822	33.0595	720	-3.874	0.0055
3 - 6	-85.4726	33.0595	720	-2.585	0.2583
3 - 7	-166.6164	33.0595	720	-5.040	<.0001
3 - 8	-103.2877	33.0595	720	-3.124	0.0681
3 - 9	-57.9110	33.0595	720	-1.752	0.8078
3 - 10	-148.5205	33.0595	720	-4.493	0.0004
3 - 11	-79.5205	33.0595	720	-2.405	0.3645
3 - 12	-78.9795	33.0595	720	-2.389	0.3751
4 - 5	-17.8219	33.0595	720	-0.539	1.0000
4 - 6	24.7877	33.0595	720	0.750	0.9996
4 - 7	-56.3562	33.0595	720	-1.705	0.8331
4 - 8	6.9726	33.0595	720	0.211	1.0000
4 - 9	52.3493	33.0595	720	1.583	0.8891
4 - 10	-38.2603	33.0595	720	-1.157	0.9866
4 - 11	30.7397	33.0595	720	0.930	0.9977
4 - 12	31.2808	33.0595	720	0.946	0.9973
5 - 6	42.6096	33.0595	720	1.289	0.9706
5 - 7	-38.5342	33.0595	720	-1.166	0.9859
5 - 8	24.7945	33.0595	720	0.750	0.9996
5 - 9	70.1712	33.0595	720	2.123	0.5614
5 - 10	-20.4384	33.0595	720	-0.618	0.9999
5 - 11	48.5616	33.0595	720	1.469	0.9296
5 - 12	49.1027	33.0595	720	1.485	0.9245
6 - 7	-81.1438	33.0595	720	-2.454	0.3336
6 - 8	-17.8151	33.0595	720	-0.539	1.0000
6 - 9	27.5616	33.0595	720	0.834	0.9991
6 - 10	-63.0479	33.0595	720	-1.907	0.7126
6 - 11	5.9521	33.0595	720	0.180	1.0000

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Table 4.14 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
6 - 12	6.4932	33.0595	720	0.196	1.0000
7 - 8	63.3288	33.0595	720	1.916	0.7070
7 - 9	108.7055	33.0595	720	3.288	0.0418
7 - 10	18.0959	33.0595	720	0.547	1.0000
7 - 11	87.0959	33.0595	720	2.635	0.2330
7 - 12	87.6370	33.0595	720	2.651	0.2249
8 - 9	45.3767	33.0595	720	1.373	0.9547
8 - 10	-45.2329	33.0595	720	-1.368	0.9556
8 - 11	23.7671	33.0595	720	0.719	0.9998
8 - 12	24.3082	33.0595	720	0.735	0.9997
9 - 10	-90.6096	33.0595	720	-2.741	0.1839
9 - 11	-21.6096	33.0595	720	-0.654	0.9999
9 - 12	-21.0685	33.0595	720	-0.637	0.9999
10 - 11	69.0000	33.0595	720	2.087	0.5870
10 - 12	69.5411	33.0595	720	2.104	0.5751
11 - 12	0.5411	33.0595	720	0.016	1.0000

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.15: *Gain* Trial contrast analysis in Medium σ^* for LPS

contrast	estimate	SE	df	t.ratio	p.value
22 - 3	-59.9795	35.5937	720	-1.685	0.8430
2 - 4	-70.2740	35.5937	720	-1.974	0.6670
2 - 5	-220.0000	35.5937	720	-6.181	<.0001
2 - 6	-133.0822	35.5937	720	-3.739	0.0091
2 - 7	-129.7397	35.5937	720	-3.645	0.0128
2 - 8	-165.3151	35.5937	720	-4.644	0.0002
2 - 9	-121.4795	35.5937	720	-3.413	0.0281
2 - 10	14.0411	35.5937	720	0.394	1.0000
2 - 11	-101.8904	35.5937	720	-2.863	0.1373
2 - 12	-25.4863	35.5937	720	-0.716	0.9998
3 - 4	-10.2945	35.5937	720	-0.289	1.0000
3 - 5	-160.0205	35.5937	720	-4.496	0.0004

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Table 4.15 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 6	-73.1027	35.5937	720	-2.054	0.6109
3 - 7	-69.7603	35.5937	720	-1.960	0.6770
3 - 8	-105.3356	35.5937	720	-2.959	0.1072
3 - 9	-61.5000	35.5937	720	-1.728	0.8209
3 - 10	74.0205	35.5937	720	2.080	0.5924
3 - 11	-41.9110	35.5937	720	-1.177	0.9848
3 - 12	34.4932	35.5937	720	0.969	0.9967
4 - 5	-149.7260	35.5937	720	-4.207	0.0015
4 - 6	-62.8082	35.5937	720	-1.765	0.8006
4 - 7	-59.4658	35.5937	720	-1.671	0.8501
4 - 8	-95.0411	35.5937	720	-2.670	0.2156
4 - 9	-51.2055	35.5937	720	-1.439	0.9383
4 - 10	84.3151	35.5937	720	2.369	0.3884
4 - 11	-31.6164	35.5937	720	-0.888	0.9984
4 - 12	44.7877	35.5937	720	1.258	0.9752
5 - 6	86.9178	35.5937	720	2.442	0.3413
5 - 7	90.2603	35.5937	720	2.536	0.2855
5 - 8	54.6849	35.5937	720	1.536	0.9072
5 - 9	98.5205	35.5937	720	2.768	0.1727
5 - 10	234.0411	35.5937	720	6.575	<.0001
5 - 11	118.1096	35.5937	720	3.318	0.0380
5 - 12	194.5137	35.5937	720	5.465	<.0001
6 - 7	3.3425	35.5937	720	0.094	1.0000
6 - 8	-32.2329	35.5937	720	-0.906	0.9981
6 - 9	11.6027	35.5937	720	0.326	1.0000
6 - 10	147.1233	35.5937	720	4.133	0.0020
6 - 11	31.1918	35.5937	720	0.876	0.9986
6 - 12	107.5959	35.5937	720	3.023	0.0904
7 - 8	-35.5753	35.5937	720	-0.999	0.9958
7 - 9	8.2603	35.5937	720	0.232	1.0000
7 - 10	143.7808	35.5937	720	4.039	0.0029
7 - 11	27.8493	35.5937	720	0.782	0.9995
7 - 12	104.2534	35.5937	720	2.929	0.1160
8 - 9	43.8356	35.5937	720	1.232	0.9788
8 - 10	179.3562	35.5937	720	5.039	<.0001
8 - 11	63.4247	35.5937	720	1.782	0.7907
8 - 12	139.8288	35.5937	720	3.928	0.0045

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Table 4.15 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
9 - 10	135.5205	35.5937	720	3.807	0.0071
9 - 11	19.5890	35.5937	720	0.550	1.0000
9 - 12	95.9932	35.5937	720	2.697	0.2032
10 - 11	-115.9315	35.5937	720	-3.257	0.0459
10 - 12	-39.5274	35.5937	720	-1.111	0.9902
11 - 12	76.4041	35.5937	720	2.147	0.5440

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.16: *Gain* Trial contrast analysis in Medium σ^* for HPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-68.8767	35.4156	720	-1.945	0.6873
2 - 4	-127.0685	35.4156	720	-3.588	0.0156
2 - 5	-128.5616	35.4156	720	-3.630	0.0135
2 - 6	-164.7055	35.4156	720	-4.651	0.0002
2 - 7	-139.3630	35.4156	720	-3.935	0.0043
2 - 8	-156.8219	35.4156	720	-4.428	0.0006
2 - 9	-207.8630	35.4156	720	-5.869	<.0001
2 - 10	-70.8699	35.4156	720	-2.001	0.6483
2 - 11	-113.2055	35.4156	720	-3.196	0.0551
2 - 12	-139.8767	35.4156	720	-3.950	0.0041
3 - 4	-58.1918	35.4156	720	-1.643	0.8632
3 - 5	-59.6849	35.4156	720	-1.685	0.8429
3 - 6	-95.8288	35.4156	720	-2.706	0.1992
3 - 7	-70.4863	35.4156	720	-1.990	0.6559
3 - 8	-87.9452	35.4156	720	-2.483	0.3161
3 - 9	-138.9863	35.4156	720	-3.924	0.0045
3 - 10	-1.9932	35.4156	720	-0.056	1.0000
3 - 11	-44.3288	35.4156	720	-1.252	0.9761
3 - 12	-71.0000	35.4156	720	-2.005	0.6457
4 - 5	-1.4932	35.4156	720	-0.042	1.0000
4 - 6	-37.6370	35.4156	720	-1.063	0.9931
4 - 7	-12.2945	35.4156	720	-0.347	1.0000

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Table 4.16 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
4 - 8	-29.7534	35.4156	720	-0.840	0.9990
4 - 9	-80.7945	35.4156	720	-2.281	0.4479
4 - 10	56.1986	35.4156	720	1.587	0.8877
4 - 11	13.8630	35.4156	720	0.391	1.0000
4 - 12	-12.8082	35.4156	720	-0.362	1.0000
5 - 6	-36.1438	35.4156	720	-1.021	0.9950
5 - 7	-10.8014	35.4156	720	-0.305	1.0000
5 - 8	-28.2603	35.4156	720	-0.798	0.9994
5 - 9	-79.3014	35.4156	720	-2.239	0.4776
5 - 10	57.6918	35.4156	720	1.629	0.8696
5 - 11	15.3562	35.4156	720	0.434	1.0000
5 - 12	-11.3151	35.4156	720	-0.319	1.0000
6 - 7	25.3425	35.4156	720	0.716	0.9998
6 - 8	7.8836	35.4156	720	0.223	1.0000
6 - 9	-43.1575	35.4156	720	-1.219	0.9803
6 - 10	93.8356	35.4156	720	2.650	0.2255
6 - 11	51.5000	35.4156	720	1.454	0.9339
6 - 12	24.8288	35.4156	720	0.701	0.9998
7 - 8	-17.4589	35.4156	720	-0.493	1.0000
7 - 9	-68.5000	35.4156	720	-1.934	0.6945
7 - 10	68.4932	35.4156	720	1.934	0.6946
7 - 11	26.1575	35.4156	720	0.739	0.9997
7 - 12	-0.5137	35.4156	720	-0.015	1.0000
8 - 9	-51.0411	35.4156	720	-1.441	0.9376
8 - 10	85.9521	35.4156	720	2.427	0.3507
8 - 11	43.6164	35.4156	720	1.232	0.9788
8 - 12	16.9452	35.4156	720	0.478	1.0000
9 - 10	136.9932	35.4156	720	3.868	0.0056
9 - 11	94.6575	35.4156	720	2.673	0.2144
9 - 12	67.9863	35.4156	720	1.920	0.7043
10 - 11	-42.3356	35.4156	720	-1.195	0.9829
10 - 12	-69.0068	35.4156	720	-1.948	0.6848
11 - 12	-26.6712	35.4156	720	-0.753	0.9996

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.17: *Gain* Trial contrast analysis in Large σ^* for LPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-130.8356	35.6569	720	-3.669	0.0117
2 - 4	-65.3904	35.6569	720	-1.834	0.7595
2 - 5	-77.3219	35.6569	720	-2.168	0.5282
2 - 6	-31.1233	35.6569	720	-0.873	0.9986
2 - 7	44.5822	35.6569	720	1.250	0.9763
2 - 8	25.6301	35.6569	720	0.719	0.9998
2 - 9	-86.9932	35.6569	720	-2.440	0.3427
2 - 10	-19.8562	35.6569	720	-0.557	1.0000
2 - 11	-24.2534	35.6569	720	-0.680	0.9999
2 - 12	-117.4589	35.6569	720	-3.294	0.0410
3 - 4	65.4452	35.6569	720	1.835	0.7586
3 - 5	53.5137	35.6569	720	1.501	0.9195
3 - 6	99.7123	35.6569	720	2.796	0.1614
3 - 7	175.4178	35.6569	720	4.920	0.0001
3 - 8	156.4658	35.6569	720	4.388	0.0007
3 - 9	43.8425	35.6569	720	1.230	0.9790
3 - 10	110.9795	35.6569	720	3.112	0.0704
3 - 11	106.5822	35.6569	720	2.989	0.0990
3 - 12	13.3767	35.6569	720	0.375	1.0000
4 - 5	-11.9315	35.6569	720	-0.335	1.0000
4 - 6	34.2671	35.6569	720	0.961	0.9969
4 - 7	109.9726	35.6569	720	3.084	0.0763
4 - 8	91.0205	35.6569	720	2.553	0.2760
4 - 9	-21.6027	35.6569	720	-0.606	0.9999
4 - 10	45.5342	35.6569	720	1.277	0.9725
4 - 11	41.1370	35.6569	720	1.154	0.9869
4 - 12	-52.0685	35.6569	720	-1.460	0.9322
5 - 6	46.1986	35.6569	720	1.296	0.9695
5 - 7	121.9041	35.6569	720	3.419	0.0276
5 - 8	102.9521	35.6569	720	2.887	0.1291
5 - 9	-9.6712	35.6569	720	-0.271	1.0000
5 - 10	57.4658	35.6569	720	1.612	0.8773
5 - 11	53.0685	35.6569	720	1.488	0.9236
5 - 12	-40.1370	35.6569	720	-1.126	0.9892
6 - 7	75.7055	35.6569	720	2.123	0.5609

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Table 4.17 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
6 - 8	56.7534	35.6569	720	1.592	0.8857
6 - 9	-55.8699	35.6569	720	-1.567	0.8957
6 - 10	11.2671	35.6569	720	0.316	1.0000
6 - 11	6.8699	35.6569	720	0.193	1.0000
6 - 12	-86.3356	35.6569	720	-2.421	0.3543
7 - 8	-18.9521	35.6569	720	-0.532	1.0000
7 - 9	-131.5753	35.6569	720	-3.690	0.0109
7 - 10	-64.4384	35.6569	720	-1.807	0.7758
7 - 11	-68.8356	35.6569	720	-1.930	0.6970
7 - 12	-162.0411	35.6569	720	-4.544	0.0003
8 - 9	-112.6233	35.6569	720	-3.159	0.0616
8 - 10	-45.4863	35.6569	720	-1.276	0.9727
8 - 11	-49.8836	35.6569	720	-1.399	0.9486
8 - 12	-143.0890	35.6569	720	-4.013	0.0032
9 - 10	67.1370	35.6569	720	1.883	0.7285
9 - 11	62.7397	35.6569	720	1.760	0.8035
9 - 12	-30.4658	35.6569	720	-0.854	0.9989
10 - 11	-4.3973	35.6569	720	-0.123	1.0000
10 - 12	-97.6027	35.6569	720	-2.737	0.1854
11 - 12	-93.2055	35.6569	720	-2.614	0.2434

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

Table 4.18: *Gain* Trial contrast analysis in Large σ^* for HPS

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-52.2877	35.6093	720	-1.468	0.9297
2 - 4	-87.7260	35.6093	720	-2.464	0.3280
2 - 5	-73.2877	35.6093	720	-2.058	0.6078
2 - 6	-51.7945	35.6093	720	-1.455	0.9338
2 - 7	-17.1575	35.6093	720	-0.482	1.0000
2 - 8	-34.8562	35.6093	720	-0.979	0.9964
2 - 9	-86.0274	35.6093	720	-2.416	0.3578
2 - 10	36.9658	35.6093	720	1.038	0.9943

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Table 4.18 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
2 - 11	-57.0411	35.6093	720	-1.602	0.8814
2 - 12	-128.9726	35.6093	720	-3.622	0.0139
3 - 4	-35.4384	35.6093	720	-0.995	0.9959
3 - 5	-21.0000	35.6093	720	-0.590	1.0000
3 - 6	0.4932	35.6093	720	0.014	1.0000
3 - 7	35.1301	35.6093	720	0.987	0.9962
3 - 8	17.4315	35.6093	720	0.490	1.0000
3 - 9	-33.7397	35.6093	720	-0.947	0.9973
3 - 10	89.2534	35.6093	720	2.506	0.3024
3 - 11	-4.7534	35.6093	720	-0.133	1.0000
3 - 12	-76.6849	35.6093	720	-2.154	0.5390
4 - 5	14.4384	35.6093	720	0.405	1.0000
4 - 6	35.9315	35.6093	720	1.009	0.9954
4 - 7	70.5685	35.6093	720	1.982	0.6618
4 - 8	52.8699	35.6093	720	1.485	0.9247
4 - 9	1.6986	35.6093	720	0.048	1.0000
4 - 10	124.6918	35.6093	720	3.502	0.0209
4 - 11	30.6849	35.6093	720	0.862	0.9988
4 - 12	-41.2466	35.6093	720	-1.158	0.9865
5 - 6	21.4932	35.6093	720	0.604	1.0000
5 - 7	56.1301	35.6093	720	1.576	0.8920
5 - 8	38.4315	35.6093	720	1.079	0.9922
5 - 9	-12.7397	35.6093	720	-0.358	1.0000
5 - 10	110.2534	35.6093	720	3.096	0.0737
5 - 11	16.2466	35.6093	720	0.456	1.0000
5 - 12	-55.6849	35.6093	720	-1.564	0.8969
6 - 7	34.6370	35.6093	720	0.973	0.9966
6 - 8	16.9384	35.6093	720	0.476	1.0000
6 - 9	-34.2329	35.6093	720	-0.961	0.9969
6 - 10	88.7603	35.6093	720	2.493	0.3105
6 - 11	-5.2466	35.6093	720	-0.147	1.0000
6 - 12	-77.1781	35.6093	720	-2.167	0.5290
7 - 8	-17.6986	35.6093	720	-0.497	1.0000
7 - 9	-68.8699	35.6093	720	-1.934	0.6946
7 - 10	54.1233	35.6093	720	1.520	0.9130
7 - 11	-39.8836	35.6093	720	-1.120	0.9896
7 - 12	-111.8151	35.6093	720	-3.140	0.0650

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Table 4.18 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
8 - 9	-51.1712	35.6093	720	-1.437	0.9388
8 - 10	71.8219	35.6093	720	2.017	0.6371
8 - 11	-22.1849	35.6093	720	-0.623	0.9999
8 - 12	-94.1164	35.6093	720	-2.643	0.2287
9 - 10	122.9932	35.6093	720	3.454	0.0246
9 - 11	28.9863	35.6093	720	0.814	0.9993
9 - 12	-42.9452	35.6093	720	-1.206	0.9818
10 - 11	-94.0068	35.6093	720	-2.640	0.2303
10 - 12	-165.9384	35.6093	720	-4.660	0.0002
11 - 12	-71.9315	35.6093	720	-2.020	0.6350

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 11 estimates

4.5.3 *Gain Error*

Below the Trial Analysis on *Gain Error* for each σ^* and for each experimental session.

Table 4.19: *Gain Error* Trial contrast analysis in Tight σ^* in LPS

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	-12.3973	31.2396	648	-0.397	1.0000
3 - 5	63.9726	31.2396	648	2.048	0.5653
3 - 6	-46.1781	31.2396	648	-1.478	0.9005
3 - 7	34.4658	31.2396	648	1.103	0.9843
3 - 8	-38.3630	31.2396	648	-1.228	0.9677
3 - 9	-41.0137	31.2396	648	-1.313	0.9506
3 - 10	-24.1164	31.2396	648	-0.772	0.9989
3 - 11	-18.9452	31.2396	648	-0.606	0.9999
3 - 12	-1.5342	31.2396	648	-0.049	1.0000
4 - 5	76.3699	31.2396	648	2.445	0.3012

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Table 4.19 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
4 - 6	-33.7808	31.2396	648	-1.081	0.9864
4 - 7	46.8630	31.2396	648	1.500	0.8921
4 - 8	-25.9658	31.2396	648	-0.831	0.9981
4 - 9	-28.6164	31.2396	648	-0.916	0.9960
4 - 10	-11.7192	31.2396	648	-0.375	1.0000
4 - 11	-6.5479	31.2396	648	-0.210	1.0000
4 - 12	10.8630	31.2396	648	0.348	1.0000
5 - 6	-110.1507	31.2396	648	-3.526	0.0163
5 - 7	-29.5068	31.2396	648	-0.945	0.9949
5 - 8	-102.3356	31.2396	648	-3.276	0.0368
5 - 9	-104.9863	31.2396	648	-3.361	0.0281
5 - 10	-88.0890	31.2396	648	-2.820	0.1319
5 - 11	-82.9178	31.2396	648	-2.654	0.1950
5 - 12	-65.5068	31.2396	648	-2.097	0.5303
6 - 7	80.6438	31.2396	648	2.581	0.2285
6 - 8	7.8151	31.2396	648	0.250	1.0000
6 - 9	5.1644	31.2396	648	0.165	1.0000
6 - 10	22.0616	31.2396	648	0.706	0.9995
6 - 11	27.2329	31.2396	648	0.872	0.9972
6 - 12	44.6438	31.2396	648	1.429	0.9179
7 - 8	-72.8288	31.2396	648	-2.331	0.3701
7 - 9	-75.4795	31.2396	648	-2.416	0.3178
7 - 10	-58.5822	31.2396	648	-1.875	0.6859
7 - 11	-53.4110	31.2396	648	-1.710	0.7899
7 - 12	-36.0000	31.2396	648	-1.152	0.9789
8 - 9	-2.6507	31.2396	648	-0.085	1.0000
8 - 10	14.2466	31.2396	648	0.456	1.0000
8 - 11	19.4178	31.2396	648	0.622	0.9998
8 - 12	36.8288	31.2396	648	1.179	0.9754
9 - 10	16.8973	31.2396	648	0.541	0.9999
9 - 11	22.0685	31.2396	648	0.706	0.9995
9 - 12	39.4795	31.2396	648	1.264	0.9612
10 - 11	5.1712	31.2396	648	0.166	1.0000
10 - 12	22.5822	31.2396	648	0.723	0.9994
11 - 12	17.4110	31.2396	648	0.557	0.9999

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

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Table 4.19 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
P value adjustment: tukey method for comparing a family of 10 estimates					

Table 4.20: *Gain Error* Trial contrast analysis in Tight σ^* in HPS

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	-40.3425	31.3668	648	-1.286	0.9566
3 - 5	46.4795	31.3668	648	1.482	0.8991
3 - 6	-81.5548	31.3668	648	-2.600	0.2196
3 - 7	9.9110	31.3668	648	0.316	1.0000
3 - 8	-58.1644	31.3668	648	-1.854	0.6999
3 - 9	-99.9452	31.3668	648	-3.186	0.0483
3 - 10	-16.1644	31.3668	648	-0.515	1.0000
3 - 11	-75.0685	31.3668	648	-2.393	0.3315
3 - 12	-70.5616	31.3668	648	-2.250	0.4239
4 - 5	86.8219	31.3668	648	2.768	0.1497
4 - 6	-41.2123	31.3668	648	-1.314	0.9504
4 - 7	50.2534	31.3668	648	1.602	0.8470
4 - 8	-17.8219	31.3668	648	-0.568	0.9999
4 - 9	-59.6027	31.3668	648	-1.900	0.6690
4 - 10	24.1781	31.3668	648	0.771	0.9989
4 - 11	-34.7260	31.3668	648	-1.107	0.9840
4 - 12	-30.2192	31.3668	648	-0.963	0.9941
5 - 6	-128.0342	31.3668	648	-4.082	0.0020
5 - 7	-36.5685	31.3668	648	-1.166	0.9771
5 - 8	-104.6438	31.3668	648	-3.336	0.0304
5 - 9	-146.4247	31.3668	648	-4.668	0.0002
5 - 10	-62.6438	31.3668	648	-1.997	0.6014
5 - 11	-121.5479	31.3668	648	-3.875	0.0046
5 - 12	-117.0411	31.3668	648	-3.731	0.0079
6 - 7	91.4658	31.3668	648	2.916	0.1032
6 - 8	23.3904	31.3668	648	0.746	0.9992
6 - 9	-18.3904	31.3668	648	-0.586	0.9999
6 - 10	65.3904	31.3668	648	2.085	0.5390
6 - 11	6.4863	31.3668	648	0.207	1.0000
6 - 12	10.9932	31.3668	648	0.350	1.0000

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Table 4.20 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
7 - 8	-68.0753	31.3668	648	-2.170	0.4785
7 - 9	-109.8562	31.3668	648	-3.502	0.0176
7 - 10	-26.0753	31.3668	648	-0.831	0.9981
7 - 11	-84.9795	31.3668	648	-2.709	0.1720
7 - 12	-80.4726	31.3668	648	-2.566	0.2363
8 - 9	-41.7808	31.3668	648	-1.332	0.9460
8 - 10	42.0000	31.3668	648	1.339	0.9442
8 - 11	-16.9041	31.3668	648	-0.539	0.9999
8 - 12	-12.3973	31.3668	648	-0.395	1.0000
9 - 10	83.7808	31.3668	648	2.671	0.1878
9 - 11	24.8767	31.3668	648	0.793	0.9987
9 - 12	29.3836	31.3668	648	0.937	0.9952
10 - 11	-58.9041	31.3668	648	-1.878	0.6841
10 - 12	-54.3973	31.3668	648	-1.734	0.7756
11 - 12	4.5068	31.3668	648	0.144	1.0000

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 4.21: *Gain Error* Trial contrast analysis in Medium σ^* in LPS

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	-125.0342	32.3709	648	-3.863	0.0048
3 - 5	15.4658	32.3709	648	0.478	1.0000
3 - 6	-87.1918	32.3709	648	-2.694	0.1784
3 - 7	-26.1370	32.3709	648	-0.807	0.9985
3 - 8	-18.1370	32.3709	648	-0.560	0.9999
3 - 9	-10.1301	32.3709	648	-0.313	1.0000
3 - 10	-157.0616	32.3709	648	-4.852	0.0001
3 - 11	-77.1849	32.3709	648	-2.384	0.3369
3 - 12	-95.0000	32.3709	648	-2.935	0.0982
4 - 5	140.5000	32.3709	648	4.340	0.0007
4 - 6	37.8425	32.3709	648	1.169	0.9767
4 - 7	98.8973	32.3709	648	3.055	0.0707
4 - 8	106.8973	32.3709	648	3.302	0.0339

Continued on next page

Table 4.21 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
4 - 9	114.9041	32.3709	648	3.550	0.0150
4 - 10	-32.0274	32.3709	648	-0.989	0.9928
4 - 11	47.8493	32.3709	648	1.478	0.9005
4 - 12	30.0342	32.3709	648	0.928	0.9955
5 - 6	-102.6575	32.3709	648	-3.171	0.0505
5 - 7	-41.6027	32.3709	648	-1.285	0.9568
5 - 8	-33.6027	32.3709	648	-1.038	0.9898
5 - 9	-25.5959	32.3709	648	-0.791	0.9987
5 - 10	-172.5274	32.3709	648	-5.330	<.0001
5 - 11	-92.6507	32.3709	648	-2.862	0.1186
5 - 12	-110.4658	32.3709	648	-3.412	0.0238
6 - 7	61.0548	32.3709	648	1.886	0.6786
6 - 8	69.0548	32.3709	648	2.133	0.5046
6 - 9	77.0616	32.3709	648	2.381	0.3392
6 - 10	-69.8699	32.3709	648	-2.158	0.4868
6 - 11	10.0068	32.3709	648	0.309	1.0000
6 - 12	-7.8082	32.3709	648	-0.241	1.0000
7 - 8	8.0000	32.3709	648	0.247	1.0000
7 - 9	16.0068	32.3709	648	0.494	1.0000
7 - 10	-130.9247	32.3709	648	-4.045	0.0024
7 - 11	-51.0479	32.3709	648	-1.577	0.8590
7 - 12	-68.8630	32.3709	648	-2.127	0.5087
8 - 9	8.0068	32.3709	648	0.247	1.0000
8 - 10	-138.9247	32.3709	648	-4.292	0.0009
8 - 11	-59.0479	32.3709	648	-1.824	0.7197
8 - 12	-76.8630	32.3709	648	-2.374	0.3430
9 - 10	-146.9315	32.3709	648	-4.539	0.0003
9 - 11	-67.0548	32.3709	648	-2.071	0.5485
9 - 12	-84.8699	32.3709	648	-2.622	0.2095
10 - 11	79.8767	32.3709	648	2.468	0.2882
10 - 12	62.0616	32.3709	648	1.917	0.6573
11 - 12	-17.8151	32.3709	648	-0.550	0.9999

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 10 estimates

Table 4.22: *Gain Error* Trial contrast analysis in Medium σ^* in HPS

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	-130.2466	32.4666	648	-4.012	0.0027
3 - 5	-153.8425	32.4666	648	-4.738	0.0001
3 - 6	-129.6918	32.4666	648	-3.995	0.0029
3 - 7	-111.3699	32.4666	648	-3.430	0.0224
3 - 8	-93.2671	32.4666	648	-2.873	0.1154
3 - 9	-46.6370	32.4666	648	-1.436	0.9154
3 - 10	-188.7877	32.4666	648	-5.815	<.0001
3 - 11	-153.6370	32.4666	648	-4.732	0.0001
3 - 12	-106.9726	32.4666	648	-3.295	0.0347
4 - 5	-23.5959	32.4666	648	-0.727	0.9993
4 - 6	0.5548	32.4666	648	0.017	1.0000
4 - 7	18.8767	32.4666	648	0.581	0.9999
4 - 8	36.9795	32.4666	648	1.139	0.9805
4 - 9	83.6096	32.4666	648	2.575	0.2316
4 - 10	-58.5411	32.4666	648	-1.803	0.7332
4 - 11	-23.3904	32.4666	648	-0.720	0.9994
4 - 12	23.2740	32.4666	648	0.717	0.9994
5 - 6	24.1507	32.4666	648	0.744	0.9992
5 - 7	42.4726	32.4666	648	1.308	0.9517
5 - 8	60.5753	32.4666	648	1.866	0.6923
5 - 9	107.2055	32.4666	648	3.302	0.0339
5 - 10	-34.9452	32.4666	648	-1.076	0.9868
5 - 11	0.2055	32.4666	648	0.006	1.0000
5 - 12	46.8699	32.4666	648	1.444	0.9130
6 - 7	18.3219	32.4666	648	0.564	0.9999
6 - 8	36.4247	32.4666	648	1.122	0.9824
6 - 9	83.0548	32.4666	648	2.558	0.2400
6 - 10	-59.0959	32.4666	648	-1.820	0.7223
6 - 11	-23.9452	32.4666	648	-0.738	0.9993
6 - 12	22.7192	32.4666	648	0.700	0.9995
7 - 8	18.1027	32.4666	648	0.558	0.9999
7 - 9	64.7329	32.4666	648	1.994	0.6037
7 - 10	-77.4178	32.4666	648	-2.385	0.3368
7 - 11	-42.2671	32.4666	648	-1.302	0.9531
7 - 12	4.3973	32.4666	648	0.135	1.0000
8 - 9	46.6301	32.4666	648	1.436	0.9155

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Table 4.22 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
8 - 10	-95.5205	32.4666	648	-2.942	0.0963
8 - 11	-60.3699	32.4666	648	-1.859	0.6965
8 - 12	-13.7055	32.4666	648	-0.422	1.0000
9 - 10	-142.1507	32.4666	648	-4.378	0.0006
9 - 11	-107.0000	32.4666	648	-3.296	0.0346
9 - 12	-60.3356	32.4666	648	-1.858	0.6972
10 - 11	35.1507	32.4666	648	1.083	0.9863
10 - 12	81.8151	32.4666	648	2.520	0.2596
11 - 12	46.6644	32.4666	648	1.437	0.9151

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 4.23: *Gain Error* Trial contrast analysis in Large σ^* in LPS

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	-131.0205	32.8269	648	-3.991	0.0029
3 - 5	-131.2740	32.8269	648	-3.999	0.0028
3 - 6	-114.1507	32.8269	648	-3.477	0.0192
3 - 7	-154.8904	32.8269	648	-4.718	0.0001
3 - 8	-224.4726	32.8269	648	-6.838	<.0001
3 - 9	-95.8082	32.8269	648	-2.919	0.1025
3 - 10	-158.6301	32.8269	648	-4.832	0.0001
3 - 11	-163.5068	32.8269	648	-4.981	<.0001
3 - 12	-82.1370	32.8269	648	-2.502	0.2692
4 - 5	-0.2534	32.8269	648	-0.008	1.0000
4 - 6	16.8699	32.8269	648	0.514	1.0000
4 - 7	-23.8699	32.8269	648	-0.727	0.9993
4 - 8	-93.4521	32.8269	648	-2.847	0.1233
4 - 9	35.2123	32.8269	648	1.073	0.9871
4 - 10	-27.6096	32.8269	648	-0.841	0.9979
4 - 11	-32.4863	32.8269	648	-0.990	0.9928
4 - 12	48.8836	32.8269	648	1.489	0.8963
5 - 6	17.1233	32.8269	648	0.522	1.0000
5 - 7	-23.6164	32.8269	648	-0.719	0.9994

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Table 4.23 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
5 - 8	-93.1986	32.8269	648	-2.839	0.1257
5 - 9	35.4658	32.8269	648	1.080	0.9865
5 - 10	-27.3562	32.8269	648	-0.833	0.9980
5 - 11	-32.2329	32.8269	648	-0.982	0.9932
5 - 12	49.1370	32.8269	648	1.497	0.8933
6 - 7	-40.7397	32.8269	648	-1.241	0.9654
6 - 8	-110.3219	32.8269	648	-3.361	0.0281
6 - 9	18.3425	32.8269	648	0.559	0.9999
6 - 10	-44.4795	32.8269	648	-1.355	0.9401
6 - 11	-49.3562	32.8269	648	-1.504	0.8907
6 - 12	32.0137	32.8269	648	0.975	0.9935
7 - 8	-69.5822	32.8269	648	-2.120	0.5142
7 - 9	59.0822	32.8269	648	1.800	0.7353
7 - 10	-3.7397	32.8269	648	-0.114	1.0000
7 - 11	-8.6164	32.8269	648	-0.262	1.0000
7 - 12	72.7534	32.8269	648	2.216	0.4466
8 - 9	128.6644	32.8269	648	3.919	0.0039
8 - 10	65.8425	32.8269	648	2.006	0.5953
8 - 11	60.9658	32.8269	648	1.857	0.6980
8 - 12	142.3356	32.8269	648	4.336	0.0007
9 - 10	-62.8219	32.8269	648	-1.914	0.6597
9 - 11	-67.6986	32.8269	648	-2.062	0.5550
9 - 12	13.6712	32.8269	648	0.416	1.0000
10 - 11	-4.8767	32.8269	648	-0.149	1.0000
10 - 12	76.4932	32.8269	648	2.330	0.3708
11 - 12	81.3699	32.8269	648	2.479	0.2819

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 4.24: *Gain Error* Trial contrast analysis in Large σ^* in HPS

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	-93.6781	32.4158	648	-2.890	0.1105
3 - 5	-99.9658	32.4158	648	-3.084	0.0652

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Table 4.24 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 6	-93.7466	32.4158	648	-2.892	0.1099
3 - 7	-79.4726	32.4158	648	-2.452	0.2971
3 - 8	-128.3219	32.4158	648	-3.959	0.0033
3 - 9	-46.5616	32.4158	648	-1.436	0.9154
3 - 10	-154.4521	32.4158	648	-4.765	0.0001
3 - 11	-106.5616	32.4158	648	-3.287	0.0355
3 - 12	-35.6644	32.4158	648	-1.100	0.9846
4 - 5	-6.2877	32.4158	648	-0.194	1.0000
4 - 6	-0.0685	32.4158	648	-0.002	1.0000
4 - 7	14.2055	32.4158	648	0.438	1.0000
4 - 8	-34.6438	32.4158	648	-1.069	0.9875
4 - 9	47.1164	32.4158	648	1.454	0.9095
4 - 10	-60.7740	32.4158	648	-1.875	0.6862
4 - 11	-12.8836	32.4158	648	-0.397	1.0000
4 - 12	58.0137	32.4158	648	1.790	0.7417
5 - 6	6.2192	32.4158	648	0.192	1.0000
5 - 7	20.4932	32.4158	648	0.632	0.9998
5 - 8	-28.3562	32.4158	648	-0.875	0.9971
5 - 9	53.4041	32.4158	648	1.647	0.8241
5 - 10	-54.4863	32.4158	648	-1.681	0.8061
5 - 11	-6.5959	32.4158	648	-0.203	1.0000
5 - 12	64.3014	32.4158	648	1.984	0.6109
6 - 7	14.2740	32.4158	648	0.440	1.0000
6 - 8	-34.5753	32.4158	648	-1.067	0.9876
6 - 9	47.1849	32.4158	648	1.456	0.9088
6 - 10	-60.7055	32.4158	648	-1.873	0.6876
6 - 11	-12.8151	32.4158	648	-0.395	1.0000
6 - 12	58.0822	32.4158	648	1.792	0.7404
7 - 8	-48.8493	32.4158	648	-1.507	0.8893
7 - 9	32.9110	32.4158	648	1.015	0.9913
7 - 10	-74.9795	32.4158	648	-2.313	0.3818
7 - 11	-27.0890	32.4158	648	-0.836	0.9980
7 - 12	43.8082	32.4158	648	1.351	0.9410
8 - 9	81.7603	32.4158	648	2.522	0.2585
8 - 10	-26.1301	32.4158	648	-0.806	0.9985
8 - 11	21.7603	32.4158	648	0.671	0.9997
8 - 12	92.6575	32.4158	648	2.858	0.1197

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Table 4.24 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
9 - 10	-107.8904	32.4158	648	-3.328	0.0312
9 - 11	-60.0000	32.4158	648	-1.851	0.7021
9 - 12	10.8973	32.4158	648	0.336	1.0000
10 - 11	47.8904	32.4158	648	1.477	0.9008
10 - 12	118.7877	32.4158	648	3.664	0.0100
11 - 12	70.8973	32.4158	648	2.187	0.4667

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

4.5.4 *SD - Error*

Below the Trial Analysis on *SD-Error*.

Table 4.25: *SD-E* Trial contrast analysis

contrast	estimate	SE	df	t.ratio	p.value
2 - 3	-52.2877	35.6093	720	-1.468	0.9297
2 - 4	-87.7260	35.6093	720	-2.464	0.3280
2 - 5	-73.2877	35.6093	720	-2.058	0.6078
2 - 6	-51.7945	35.6093	720	-1.455	0.9338
2 - 7	-17.1575	35.6093	720	-0.482	1.0000
2 - 8	-34.8562	35.6093	720	-0.979	0.9964
2 - 9	-86.0274	35.6093	720	-2.416	0.3578
2 - 10	36.9658	35.6093	720	1.038	0.9943
2 - 11	-57.0411	35.6093	720	-1.602	0.8814
2 - 12	-128.9726	35.6093	720	-3.622	0.0139
3 - 4	-35.4384	35.6093	720	-0.995	0.9959
3 - 5	-21.0000	35.6093	720	-0.590	1.0000
3 - 6	0.4932	35.6093	720	0.014	1.0000
3 - 7	35.1301	35.6093	720	0.987	0.9962
3 - 8	17.4315	35.6093	720	0.490	1.0000
3 - 9	-33.7397	35.6093	720	-0.947	0.9973

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Table 4.25 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 10	89.2534	35.6093	720	2.506	0.3024
3 - 11	-4.7534	35.6093	720	-0.133	1.0000
3 - 12	-76.6849	35.6093	720	-2.154	0.5390
4 - 5	14.4384	35.6093	720	0.405	1.0000
4 - 6	35.9315	35.6093	720	1.009	0.9954
4 - 7	70.5685	35.6093	720	1.982	0.6618
4 - 8	52.8699	35.6093	720	1.485	0.9247
4 - 9	1.6986	35.6093	720	0.048	1.0000
4 - 10	124.6918	35.6093	720	3.502	0.0209
4 - 11	30.6849	35.6093	720	0.862	0.9988
4 - 12	-41.2466	35.6093	720	-1.158	0.9865
5 - 6	21.4932	35.6093	720	0.604	1.0000
5 - 7	56.1301	35.6093	720	1.576	0.8920
5 - 8	38.4315	35.6093	720	1.079	0.9922
5 - 9	-12.7397	35.6093	720	-0.358	1.0000
5 - 10	110.2534	35.6093	720	3.096	0.0737
5 - 11	16.2466	35.6093	720	0.456	1.0000
5 - 12	-55.6849	35.6093	720	-1.564	0.8969
6 - 7	34.6370	35.6093	720	0.973	0.9966
6 - 8	16.9384	35.6093	720	0.476	1.0000
6 - 9	-34.2329	35.6093	720	-0.961	0.9969
6 - 10	88.7603	35.6093	720	2.493	0.3105
6 - 11	-5.2466	35.6093	720	-0.147	1.0000
6 - 12	-77.1781	35.6093	720	-2.167	0.5290
7 - 8	-17.6986	35.6093	720	-0.497	1.0000
7 - 9	-68.8699	35.6093	720	-1.934	0.6946
7 - 10	54.1233	35.6093	720	1.520	0.9130
7 - 11	-39.8836	35.6093	720	-1.120	0.9896
7 - 12	-111.8151	35.6093	720	-3.140	0.0650
8 - 9	-51.1712	35.6093	720	-1.437	0.9388
8 - 10	71.8219	35.6093	720	2.017	0.6371
8 - 11	-22.1849	35.6093	720	-0.623	0.9999
8 - 12	-94.1164	35.6093	720	-2.643	0.2287
9 - 10	122.9932	35.6093	720	3.454	0.0246
9 - 11	28.9863	35.6093	720	0.814	0.9993
9 - 12	-42.9452	35.6093	720	-1.206	0.9818
10 - 11	-94.0068	35.6093	720	-2.640	0.2303

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Table 4.25 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
10 - 12	-165.9384	35.6093	720	-4.660	0.0002
11 - 12	-71.9315	35.6093	720	-2.020	0.6350

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

4.5.5 Bucket length σ_U

Below the σ_t^U Trial Analysis for each σ^*.

Table 4.26: σ_U Trial contrast analysis in Tight σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	134.7877	25.5900	1378	5.267	<.0001
3 - 5	232.2945	25.5900	1378	9.078	<.0001
3 - 6	293.5000	25.5900	1378	11.469	<.0001
3 - 7	318.7226	25.5900	1378	12.455	<.0001
3 - 8	389.1644	25.5900	1378	15.208	<.0001
3 - 9	394.5616	25.5900	1378	15.419	<.0001
3 - 10	394.6062	25.5900	1378	15.420	<.0001
3 - 11	414.6130	25.5900	1378	16.202	<.0001
3 - 12	436.5856	25.5900	1378	17.061	<.0001
4 - 5	97.5068	25.5900	1378	3.810	0.0056
4 - 6	158.7123	25.5900	1378	6.202	<.0001
4 - 7	183.9349	25.5900	1378	7.188	<.0001
4 - 8	254.3767	25.5900	1378	9.940	<.0001
4 - 9	259.7740	25.5900	1378	10.151	<.0001
4 - 10	259.8185	25.5900	1378	10.153	<.0001
4 - 11	279.8253	25.5900	1378	10.935	<.0001
4 - 12	301.7979	25.5900	1378	11.794	<.0001
5 - 6	61.2055	25.5900	1378	2.392	0.3314
5 - 7	86.4281	25.5900	1378	3.377	0.0260
5 - 8	156.8699	25.5900	1378	6.130	<.0001

Continued on next page

Table 4.26 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
5 - 9	162.2671	25.5900	1378	6.341	<.0001
5 - 10	162.3116	25.5900	1378	6.343	<.0001
5 - 11	182.3185	25.5900	1378	7.125	<.0001
5 - 12	204.2911	25.5900	1378	7.983	<.0001
6 - 7	25.2226	25.5900	1378	0.986	0.9931
6 - 8	95.6644	25.5900	1378	3.738	0.0074
6 - 9	101.0616	25.5900	1378	3.949	0.0033
6 - 10	101.1062	25.5900	1378	3.951	0.0033
6 - 11	121.1130	25.5900	1378	4.733	0.0001
6 - 12	143.0856	25.5900	1378	5.591	<.0001
7 - 8	70.4418	25.5900	1378	2.753	0.1541
7 - 9	75.8390	25.5900	1378	2.964	0.0898
7 - 10	75.8836	25.5900	1378	2.965	0.0894
7 - 11	95.8904	25.5900	1378	3.747	0.0071
7 - 12	117.8630	25.5900	1378	4.606	0.0002
8 - 9	5.3973	25.5900	1378	0.211	1.0000
8 - 10	5.4418	25.5900	1378	0.213	1.0000
8 - 11	25.4486	25.5900	1378	0.994	0.9926
8 - 12	47.4212	25.5900	1378	1.853	0.7008
9 - 10	0.0445	25.5900	1378	0.002	1.0000
9 - 11	20.0514	25.5900	1378	0.784	0.9988
9 - 12	42.0240	25.5900	1378	1.642	0.8271
10 - 11	20.0068	25.5900	1378	0.782	0.9988
10 - 12	41.9795	25.5900	1378	1.640	0.8280
11 - 12	21.9726	25.5900	1378	0.859	0.9976

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 4.27: σ_U Trial contrast analysis in Medium σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	114.8596	28.3985	1378	4.045	0.0022
3 - 5	188.4178	28.3985	1378	6.635	<.0001
3 - 6	255.1781	28.3985	1378	8.986	<.0001

Continued on next page

Table 4.27 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
3 - 7	300.4795	28.3985	1378	10.581	<.0001
3 - 8	298.8733	28.3985	1378	10.524	<.0001
3 - 9	327.6575	28.3985	1378	11.538	<.0001
3 - 10	319.5479	28.3985	1378	11.252	<.0001
3 - 11	281.1815	28.3985	1378	9.901	<.0001
3 - 12	316.0308	28.3985	1378	11.128	<.0001
4 - 5	73.5582	28.3985	1378	2.590	0.2231
4 - 6	140.3185	28.3985	1378	4.941	<.0001
4 - 7	185.6199	28.3985	1378	6.536	<.0001
4 - 8	184.0137	28.3985	1378	6.480	<.0001
4 - 9	212.7979	28.3985	1378	7.493	<.0001
4 - 10	204.6884	28.3985	1378	7.208	<.0001
4 - 11	166.3219	28.3985	1378	5.857	<.0001
4 - 12	201.1712	28.3985	1378	7.084	<.0001
5 - 6	66.7603	28.3985	1378	2.351	0.3568
5 - 7	112.0616	28.3985	1378	3.946	0.0033
5 - 8	110.4555	28.3985	1378	3.889	0.0041
5 - 9	139.2397	28.3985	1378	4.903	<.0001
5 - 10	131.1301	28.3985	1378	4.618	0.0002
5 - 11	92.7637	28.3985	1378	3.266	0.0371
5 - 12	127.6130	28.3985	1378	4.494	0.0003
6 - 7	45.3014	28.3985	1378	1.595	0.8507
6 - 8	43.6952	28.3985	1378	1.539	0.8764
6 - 9	72.4795	28.3985	1378	2.552	0.2418
6 - 10	64.3699	28.3985	1378	2.267	0.4116
6 - 11	26.0034	28.3985	1378	0.916	0.9960
6 - 12	60.8527	28.3985	1378	2.143	0.4973
7 - 8	-1.6062	28.3985	1378	-0.057	1.0000
7 - 9	27.1781	28.3985	1378	0.957	0.9944
7 - 10	19.0685	28.3985	1378	0.671	0.9997
7 - 11	-19.2979	28.3985	1378	-0.680	0.9996
7 - 12	15.5514	28.3985	1378	0.548	0.9999
8 - 9	28.7842	28.3985	1378	1.014	0.9915
8 - 10	20.6747	28.3985	1378	0.728	0.9993
8 - 11	-17.6918	28.3985	1378	-0.623	0.9998
8 - 12	17.1575	28.3985	1378	0.604	0.9999
9 - 10	-8.1096	28.3985	1378	-0.286	1.0000

Continued on next page

Table 4.27 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
9 - 11	-46.4760	28.3985	1378	-1.637	0.8300
9 - 12	-11.6267	28.3985	1378	-0.409	1.0000
10 - 11	-38.3664	28.3985	1378	-1.351	0.9414
10 - 12	-3.5171	28.3985	1378	-0.124	1.0000
11 - 12	34.8493	28.3985	1378	1.227	0.9680

Note: contrasts are still on the rank scale
Degrees-of-freedom method: kenward-roger
P value adjustment: tukey method for comparing a family of 10 estimates

Table 4.28: σ_U Trial contrast analysis in Large σ^*

contrast	estimate	SE	df	t.ratio	p.value
3 - 4	99.9247	28.0935	1378	3.557	0.0142
3 - 5	115.7466	28.0935	1378	4.120	0.0016
3 - 6	148.0103	28.0935	1378	5.268	<.0001
3 - 7	145.8870	28.0935	1378	5.193	<.0001
3 - 8	128.0274	28.0935	1378	4.557	0.0002
3 - 9	123.7842	28.0935	1378	4.406	0.0005
3 - 10	127.1952	28.0935	1378	4.528	0.0003
3 - 11	105.6815	28.0935	1378	3.762	0.0068
3 - 12	93.0719	28.0935	1378	3.313	0.0320
4 - 5	15.8219	28.0935	1378	0.563	0.9999
4 - 6	48.0856	28.0935	1378	1.712	0.7890
4 - 7	45.9623	28.0935	1378	1.636	0.8303
4 - 8	28.1027	28.0935	1378	1.000	0.9923
4 - 9	23.8596	28.0935	1378	0.849	0.9977
4 - 10	27.2705	28.0935	1378	0.971	0.9938
4 - 11	5.7568	28.0935	1378	0.205	1.0000
4 - 12	-6.8527	28.0935	1378	-0.244	1.0000
5 - 6	32.2637	28.0935	1378	1.148	0.9795
5 - 7	30.1404	28.0935	1378	1.073	0.9872
5 - 8	12.2808	28.0935	1378	0.437	1.0000
5 - 9	8.0377	28.0935	1378	0.286	1.0000
5 - 10	11.4486	28.0935	1378	0.408	1.0000
5 - 11	-10.0651	28.0935	1378	-0.358	1.0000

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Table 4.28 – continued from previous page

contrast	estimate	SE	df	t.ratio	p.value
5 - 12	-22.6747	28.0935	1378	-0.807	0.9985
6 - 7	-2.1233	28.0935	1378	-0.076	1.0000
6 - 8	-19.9829	28.0935	1378	-0.711	0.9994
6 - 9	-24.2260	28.0935	1378	-0.862	0.9975
6 - 10	-20.8151	28.0935	1378	-0.741	0.9992
6 - 11	-42.3288	28.0935	1378	-1.507	0.8897
6 - 12	-54.9384	28.0935	1378	-1.956	0.6306
7 - 8	-17.8596	28.0935	1378	-0.636	0.9998
7 - 9	-22.1027	28.0935	1378	-0.787	0.9988
7 - 10	-18.6918	28.0935	1378	-0.665	0.9997
7 - 11	-40.2055	28.0935	1378	-1.431	0.9175
7 - 12	-52.8151	28.0935	1378	-1.880	0.6828
8 - 9	-4.2432	28.0935	1378	-0.151	1.0000
8 - 10	-0.8322	28.0935	1378	-0.030	1.0000
8 - 11	-22.3459	28.0935	1378	-0.795	0.9987
8 - 12	-34.9555	28.0935	1378	-1.244	0.9650
9 - 10	3.4110	28.0935	1378	0.121	1.0000
9 - 11	-18.1027	28.0935	1378	-0.644	0.9998
9 - 12	-30.7123	28.0935	1378	-1.093	0.9854
10 - 11	-21.5137	28.0935	1378	-0.766	0.9990
10 - 12	-34.1233	28.0935	1378	-1.215	0.9701
11 - 12	-12.6096	28.0935	1378	-0.449	1.0000

Note: contrasts are still on the rank scale

Degrees-of-freedom method: kenward-roger

P value adjustment: tukey method for comparing a family of 10 estimates

CHAPTER 5

GENERAL CONCLUSION

5.0.1 General Conclusion

Sport and physical activity could be important for the growth of the individuals. This concerning the psychological, psycho-social and physiological sides (Biddle and Asare, 2011; Biddle et al., 2019; Zhu et al., 2014).

This thesis project investigated how sports practice could modulate high-order cognitive function in both young and adult athletes. In particular, the attention was directed to decision-making ability under uncertainty (Sub-chapter 1.3.1). In particular, we tested the ability to create an internal model of an uncertain environment and how participants adapt their behaviour. Moreover, in the present project, we analysed how adults change their behaviour when exposed to stressful situations.

To analyse the decision-making ability of sports athletes, we started with the selection of the task. Specifically, we opted for a statistical decision task (Berger, 1990) where participants had to make decisions under uncertainty, and they have to make them according to the available information. We hypothesised that open-skill athletes should be better able to analyse partial information and create an internal model of an environment compared to closed-skill athletes and non-athletes. This is because of the nature of open-skill sports; these athletes should adapt or modify their actions according to what is happening in that particular situation, choosing the most appropriate option to reach the goal (Raab, 2007). However, decision-making abilities are also influenced by various personality characteristics, such as personality traits and high-order cognitive function (e.g., intelligence; Del Missier et al. 2012; Gonzaga et al. 2014; Gonzalez et al. 2005). Thus, before starting the data collection on athletes, the first experiment was performed to examine the psychological and psycho-social characteristics involved in the task's decision-making capabilities (Subchapter 1.3.1). To be precise, we analysed personality characteristics such as Extra/Introversion, Neuroticism (Eysenck and Eysenck, 1994) and Trait Anxiety (Spielberger, 1983) and cognitive functions such as fluid intelligence (Raven, 1958; Raven and Court, 1998; Raven). As reported in Study 1 (Chapter 2), these factors could modulate the decision-making ability. However, in this experiment, only an effect of intelligence was found, while the personality traits did not influence participants' behaviour. In particular, the results highlighted that highly intelligent participants were able to analyse the direction of the events better; thus, they were better able to find the best location to set the bucket than normally intelligent participants. This ability brought highly intelligent participants to the collection of more points compared to normally intelligent.

In the second and third studies (Chapter 3 and Chapter 4, respectively), we tested decision abilities under uncertainty of young and adult open- and closed-skill athletes controlling for fluid intelligence (Raven; Raven and Court, 1998). Moreover, only in adult participants, we tested athletes' decision-making abilities inducing a stressful state, and we compared the data recruiting a control group of non-athletes.

Study 2 (Chapter 3), in which decision-making was analysed in pre-adolescent athletes, revealed that intelligence did not affect the decision-making processes. However, sports activity affected them. In particular, we found that open-skill sports athletes could better compute dots' average direction than closed-skill sports athletes. Nevertheless, this better ability did not lead to a high score for young open-skill athletes than closed-skill ones. Furthermore, the results showed that young open-skill athletes modulated the bucket better and closed-skills athletes. In particular, they were able to modulate the bucket according to the uncertainty. This could be seen as a sign of better awareness about the decisions taken in the task.

In the third experiment (Chapter 4), in which adult athletes of open- and closed-skill sports were recruited, similar results of Study 1 (Chapter 2) emerged. Specifically, we found an effect of intelligence where highly intelligent participants were better able to compute the average of the dots' direction than normally intelligent participants. However, contrary to what was found in Study 1 (Chapter 2), this better able did not lead to a higher score in highly intelligent participants than normally intelligent ones. Moreover, the results showed no differences between open- and closed-skill athletes. Whereas, regarding stressful effects on the decision process, the study partially confirmed *PET* and *ACT* assumptions (Eysenck and Calvo, 1992; Eysenck et al., 2007). Firstly, the analysis revealed that participants were able to maintain stable performance. However, the analysis on the bucket length's modulation revealed that participants, when exposed to high pressure and when the uncertainty was high, put in action less risky behaviour. This could be associated with a stressful state, in which anxious participants were less inclined to make risky choices. Furthermore, our results on pressure induction revealed an increment of HR and mental resources when exposed to high pressure compared to low-pressure session. However, the State Anxiety questionnaire did not reveal differences between the two experimental sessions. This could be due to the questionnaire involved in the task. To be precise, we employed the State Anxiety questionnaire, (Spielberger, 1983) which may not have been appropriate for our research design. It is possible that to better understand the effect of pressure induction, the

Competitive State Anxiety Inventory - SCAI questionnaire (Martens et al., 1990) would have been more appropriate for that particular situation. Indeed, in this questionnaire, participants are asked their feelings about the competition; thus, it is more suitable for our research design. Furthermore, eye-tracking data revealed that the pressure induction did not modulate the participants' visual search behaviour. In particular, as reported in Chapter 4, we expected a shift of attention to the threatening or irrelevant stimuli of the task, but participants' visual behaviour was similar in the two experimental sessions.

This could be due to the low salience of the threatening stimuli. In particular, we gave participants twelve seconds in each trial to respond, and the points increased and decreased linearly by 2 points every 2° of the length of the bucket. Thus, participants may not have given much importance to this information. However, in general, our results indicated that intelligence could be important, but only in adulthood and not in childhood. In contrast, sports practice seemed to have an important role in developmental age but not in adulthood. In particular, our results highlighted differences between young open- and closed-skills athletes where the open-skill athletes were able to perform the task slightly better than closed-skill sports athletes; in particular, the former were better able to create an internal model of the environment than closed-skill athletes. Thus, based of cognitive theory of transfer (Catrambone and Holyoak, 1989; Wagner, 2006; Goldstone and Sakamoto, 2003), the results claim that some sports activities could help more in individuals' development than others. However, the nonsignificant differences between adult open- and closed-skill athletes could be explained by the age dependence theory (Hötting and Röder, 2013). Specifically, it is possible that the cognitive benefits of physical activity are more likely to occur in childhood compared to young adulthood.

These results should be taken into account when physical education teachers are programming their lessons. In particular, teachers should promote activities with moderate to high cognitive demand characterised by a high level of uncertainty. As a consequence, the physical education lessons can be important for the enhancement of the pupils' abilities in the other school subjects.

A general further interesting point to consider is that all participants tested (adults and pre-adolescents) set the bucket larger than necessary when the uncertainty was low. Consequently, it is possible to assume that when participants faced the medium and large σ^*, they were pushed to widen the bucket in order to collect points. In contrast, when they faced the low uncertainty environment (Tight σ^*), they were not aware and/or confident about the possibility to maximise the score (Kepecs and Mainen, 2012). Another possible explanation may reside in the *Prospect theory* (Kahneman and Tversky, 1979). This theory postulated that for humans, the losses are more important than the gain; thus, in this experiment, we may hypothesise that participants were more oriented to collect points than maximise the gain. Another possible explanation is the influence of the large σ^*s on the tight ones. However, if this hypothesis was true, we should not find differences on σ^U among the three conditions. This behaviour has already been seen in the "*Balloon Analogue Risk-Taking*" task, (Lejuez et al., 2002) where participants were not able to maximise the score when the probability of making a profit was favourable.

5.0.2 Future studies

In this research project, some questions remain open; thus, other experiments should be implemented to understand better the behaviour employed in this task. For instance, in this project, we adopted a linear pay-off matrix in which the number of possible points gained increased/decreased two points every two grades of length. However, it is conceivable that this linear pay-off matrix could not reveal all the differences between and across the groups deeply. Thus, in the next studies could be possible to involve different pay-off matrix. Based on the pay-matrix involved, the optimal behaviour and the strategies employed to maximise the score could change significantly.

However, this is a common concern when decision-making tasks involve a pay-off matrix. An example is the research of Persaud et al. 2007, where the optimal strategy was to bet higher even if the selected choice's confidence was low (Clifford et al., 2008).

In our case, it is possible that with this continuous linear pay-off matrix, participants were not able to completely understand how much they had to bet to maximise the score. Alternatively, this pay-off matrix did not adequately differentiate the performance of the groups. Additionally, to better understand the effect of sports practice in childhood, the recruitment of a control group and the increment of the sample of young open- and closed-skill sports athletes should be made.

Another possible improvement for future studies is the involvement of paid rewards. Indeed, in these experiments, participants employed only a motivational pulse; thus, it is very likely that some participants did not have the perfect motivational pulse to perform well in the experiment. This is particularly important when stressful conditions were investigated, as we did in Chapter 4.

Another possible study to better understand the modulation of the bucket is the presentation of the three σ^*s separately. In this way, it is possible to understand whether there is an effect of one σ^* on the others (e.g., Large σ^* and Medium σ^* on Tight σ^*).

APPENDIX

A

APPENDIX A

Approvals of bio-ethics committee of University of Bologna of the studies involved in the PhD project (Fig. A.1 and Fig. A.2). Moreover, it is reported the informed consent and privacy forms for adults and young people (Fig. A.3 and Fig. A.4, Fig. A.5 and Fig. A.6), respectively.

***ALMA MATER STUDIORUM* – UNIVERSITA' DI BOLOGNA**

COMITATO DI BIOETICA

VERBALE DI RIUNIONE

Prot. 25057 del 7/2/2018

Mauro BERNARDI (Presidente)
Diletta TEGA (Vice Presidente)
Massimo FRANZONI
Annalisa GUARINI
Marina LALATTA COSTERBOSA
Andrea MARTONI
Rossella MIGLIO
Giampaolo PECCOLO
Susi PELOTTI
Elisabetta POLUZZI

Oggi, venerdì 26 gennaio 2018

OMISSIS

Progetto di ricerca: *"Il collegamento tra le performance sportive e le capacità decisionali degli atleti in domini non-sportivi"*, proponente Prof. Alessia Tessari, Dipartimento di Psicologia.

Il Comitato di Bioetica, preso atto del parere positivo espresso dal Comitato Etico del Dipartimento di Psicologia, con esclusivo riferimento ai profili bioetici, esprime unanime **parere favorevole** in merito al progetto di ricerca: *"Il collegamento tra le performance sportive e le capacità decisionali degli atleti in domini non-sportivi"*, proponente Prof. Alessia Tessari, Dipartimento di Psicologia.

OMISSIS

IL SEGRETARIO
Dr. Silvana Fracasso

IL PRESIDENTE
Prof. Mauro Bernardi

1

Figure A.1: Bio-ethics Approval

***ALMA MATER STUDIORUM* – UNIVERSITA' DI BOLOGNA**

COMITATO DI BIOETICA

VERBALE DI RIUNIONE

Prot. 142212 del /10/10/2018

Mauro BERNARDI (Presidente)
Diletta TEGA (Vice Presidente)
Massimo FRANZONI
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Marina LALATTA COSTERBOSA
Andrea MARTONI
Rossella MIGLIO
Giampaolo PECCOLO
Susi PELOTTI
Elisabetta POLUZZI

Oggi, lunedì 24 settembre 2018

OMISSIS

Progetto di ricerca: *"Il collegamento tra le performance sportive e le capacità decisionali degli atleti in domini non-sportivi"*, proponente Dr. Alessia Tessari, Dipartimento di Psicologia. Estensione.

Il Comitato di Bioetica, in merito progetto di ricerca *"Il collegamento tra le performance sportive e le capacità decisionali degli atleti in domini non-sportivi"*, proponente Dr. Alessia Tessari, Dipartimento di Psicologia, prende atto delle modifiche apportate al progetto, nello specifico, di coinvolgere nello studio anche giovani atleti di età compresa tra i 9 e gli 11 anni, e conferma il proprio parere favorevole espresso in data 26.1.2018.

OMISSIS

IL SEGRETARIO
Dr. Silvana Fracasso

IL PRESIDENTE
Prof. Mauro Bernardi

Figure A.2: Bio-ethics Approval

Modulo Informativo per la partecipazione – Consenso Informato

1. **IL COLLEGAMENTO TRA LE PERFOMANCE SPORTIVE E LE CAPACITA' DECISIONALI DEGLI ATLETI IN DOMINI NON SPORTIVI - responsabili Prof.ssa Tessari e Prof. Ceciliani**

Gentile Signora/Signore,

Lei è invitata/o a prendere parte a una ricerca condotta nel quadro del progetto "Il collegamento tra lee performance sportive e le capacità decisionali degli atleti in domini non sportivi" di cui sono responsabili la Prof.ssa Alessia Tessari e il Prof. Andrea Ceciliani. Prima di decidere se partecipare è importante che abbia tutte le informazioni necessarie per aderire in modo consapevole e responsabile. Le chiediamo di leggere questo documento e di fare a chi le ha proposto questo studio tutte le domande che ritiene opportune.

2. **Breve descrizione e Obiettivi**

Il progetto di ricerca ha come obiettivo quello di studiare il collegamento tra attività sportiva e capacità decisionali in contesti non-sportivi. Per raggiungere questo obiettivo, i ricercatori impegnati nel progetto si propongono di raccogliere e analizzare, attraverso un compito cognitivo ed uno decisionale, una serie di dati che permetteranno di valutare tali capacità. Prima di iniziare Le verrà chiesto di compilare alcuni questionari, e una parte dei quali le verranno somministrati nuovamente alla fine del test cognitivo e di quello decisionale.
Inoltre, durante i compiti verranno registrai alcuni suoi parametri fisiologici come la frequenza cardiaca, la conduttanza cutanea e la contrazione di alcuni muscoli.

3. **Cosa comporta la partecipazione allo studio?**

La partecipazione al progetto di ricerca comporta il completamento di tre questionari denominati State Questionario ansia di tratto e stato - STAI (Spielberger, 1982), Questionario sull'ansia competitiva CSAI-2 (Martens et al. 1990), Quastionario di Personalità di Eysenck EPQ-R (Eysenck 4 Eysenck, 1994 e il The Life Managment: Selection, Optimization and Compensation (Baltes et al., 1999), i quali permetteranno di identificare alcuni suoi aspetti psicologici. La durata prevista del completamento dei questionari è di circa 20 minuti. Successivamente verrà fatto accomodare davanti ad un computer nel quale verranno presentati due compiti. Il primo compito è un compito relativo alle capacità cognitive (durata ca. 20 min), mentre il secondo riguarda un compito decisionale (durata ca. 30 min) in cui dovrà valutare ogni risposta che intende prendere. Inoltre, alla fine di ogni compito le verrà chiesto di ri-compilare due dei questionari precedentemente compilati (STAI e CSAI-2) e di valutare attraverso la scala di valutazione dello sforzo mentale effettuato – RSME.

4. **Benefici, disagi e/o rischi potenziali della partecipazione**

La partecipazione allo studio è volontaria e gratuita. Per i partecipanti la collaborazione non comporta nessun tipo di rischio o disagio.

5. **Ritiro dallo studio**

Lei ha il diritto di ritirare in qualsiasi momento il suo consenso alla partecipazione a questo studio, anche senza preavviso o motivazione specifica.

6. **Restituzione**

Lei ha diritto a richiedere informazioni sui risultati e sull'esito della ricerca.

7. **Misure previste per tutelare l'anonimato**

L'elaborazione dei dati raccolti sarà condotta in modo da eliminare qualsiasi riferimento che possa permettere di ricollegare singole affermazioni ad una determinata persona. I risultati della ricerca saranno pubblicati in forma riassuntiva e in nessun caso eventuali brevi citazioni saranno riconducibili a singole persone.

8. **Contatti**

Per qualsiasi informazione e chiarimento su questo studio o per qualsiasi necessità può rivolgersi al dottorando Gabriele Russo (gabriele.russo5@unibo.it) che è a sua disposizione per ulteriori informazioni o chiarimenti.

Consenso informato alla partecipazione allo studio

Il/la sottoscritto/a ______________________ residente in ____________________,

via ____________________________________

DICHIARA

- di aver letto il suddetto foglio informativo ricevuto, di aver compreso sia le informazioni in esso contenute sia le informazioni fornite in forma orale dal personale addetto al progetto di ricerca "Il ruolo delle competenze nelle capacità decisionali" e di aver avuto ampio tempo ed opportunità di porre domande ed ottenere risposte soddisfacenti dal personale addetto;
- di aver compreso che la partecipazione allo studio è del tutto volontaria e libera, che ci si potrà ritirare dallo studio in qualsiasi momento, senza dover dare spiegazioni e senza che ciò comporti alcuno svantaggio o pregiudizio;
- di aver compreso la natura e le attività che la partecipazione allo studio comportano e i relativi rischi;
- di aver compreso che la partecipazione a questo studio non comporterà il riconoscimento di alcun vantaggio di natura economica diretto o indiretto.

Conseguentemente, il/la sottoscritto/a

☐ACCONSENTE ☐ NON ACCONSENTE

a partecipare allo studio, nella consapevolezza che tale consenso è manifestato liberamente ed è revocabile in ogni momento senza che ciò comporti alcuno svantaggio o pregiudizio.

_______________, _______________

(luogo e data)

____

(firma)

____

(firma di chi raccoglie il consenso)

Modulo Informativo per la partecipazione – Consenso Informato (INTEGRAZIONE FINALE)

Gentile Signora/Signore,

Lei ha preso parte ad un esperimento in cui l'obiettivo è stato quello di farle prendere decisioni sotto condizioni di ansia. In modo da aumentare la sua ansia di stato, le è stato detto che le performance registrare nel compito decisional verranno valutate e verrà stilata una classica sulla base dei risultati ottenuti dai vari partecipanti.. Ovviamente tutto ciò non avverrà e ha comunque il diritto di richiedere informaizoni riguardo ai risultati, come specificato nel punto **8** del consenso informato, precedentemente firmato. Inoltre, i questionari che ha completato dopo ogni compito e le variabili fisiologiche registrate, hanno l'obiettivo di capire se vi è stato realmente un aumento dello stato di ansia sia somatico che cognitivo durante l'esecuzione del compito.

Consenso informato alla partecipazione allo studio

Il/la sottoscritto/a ______________________ residente in ____________________,

via ____________________________________

DICHIARA

- di aver letto il suddetto foglio informativo ricevuto, di aver compreso sia le informazioni in esso contenute sia le informazioni fornite in forma orale dal personale addetto al progetto di ricerca "Il ruolo delle competenze nelle capacità decisionali" e di aver avuto ampio tempo ed opportunità di porre domande ed ottenere risposte soddisfacenti dal personale addetto;
- di aver compreso che la partecipazione allo studio è del tutto volontaria e libera, che ci si potrà ritirare dallo studio in qualsiasi momento, senza dover dare spiegazioni e senza che ciò comporti alcuno svantaggio o pregiudizio;
- di aver compreso la natura e le attività che la partecipazione allo studio comportano e i relativi rischi;
- di aver compreso che la partecipazione a questo studio non comporterà il riconoscimento di alcun vantaggio di natura economica diretto o indiretto.

Conseguentemente, il/la sottoscritto/a

☐ACCONSENTE ☐ NON ACCONSENTE

a partecipare allo studio, nella consapevolezza che tale consenso è manifestato liberamente ed è revocabile in ogni momento senza che ciò comporti alcuno svantaggio o pregiudizio.

_______________, _______________

(luogo e data)

____

(firma)

____

(firma di chi raccoglie il consenso)

Figure A.3: Informed consent for adults

Modulo Informativo per il trattamento dei dati

Informativa sulla protezione dei dati personali (ex artt. 12, 13 e 14 Regolamento 2016/679)

Ai sensi dell'art. 13 del D.lgs. 196/2003, si nforma che l'Alma Mater Studiorum - Università di Bologna procederà al trattamento dei dati forniti esclusivamente per fini istituzionali (art. 4 del D.R. 271/2009) e nel rispetto della normativa in materia di protezione dei dati personali.

1. **Finalità dei dati**

I dati saranno trattati, anche con l'ausilio di mezzi elettronici, per finalità di ricerca scientifica, nell'ambito del progetto di ricerca intitolato " **IL COLLEGAMENTO TRA LE PERFOMANCE SPORTIVE E LE CAPACITA' DECISIONALI DEGLI ATLETI IN DOMINI NON SPORTIVI - responsabile Prof.ssa Tessari**".
La ricerca è finalizzata allo studio delle capacità decisionali in contesti non sportivi. Per fare ciò, verranno registrati i tempi di risposta e le risposte dei partecipanti ad un test cognitivo e ad uno decisionale. Le risposte al test saranno raccolte in un'unica sessione sperimentale.

2. **Modalità di trattamento, conservazione e diffusione dei dati**

I dati verranno raccolti e conservati in modo che l'identificazione della persona sia prevenuta con i mezzi tecnologici disponibili, come ad esempi password crittografate. Il trattamento però si avvarrà di un codice che le sarà assegnato al momento del coinvolgimento e che servirà ad identificare il soggetto con i dati registrati. Per tale ragione si renderà necessario conservare l'associazione codice/utente fino al termine della ricerca (~A.A. 2019/20). La conservazione dei codici associativi avverrà tramite modalità protette da password crittografate. Si precisa che nessun ricercatore potrà mai elaborare i risultati con lo scopo di identificare i partecipanti e diffondere la loro identità. I dati, infatti, verranno sempre analizzati in forma collettiva, con l'obiettivo di estrarre i risultati emersi. Si precisa in fine che, per nessun motivo, saranno forniti i dati identificativi a persone terze.

3. **Soggetti del trattamento**

Il Titolare del trattamento è l'Alma Mater Studiorum - Università di Bologna – Via Zamboni, 33 40126 Bologna (BO). I Responsabili del trattamento sono il Direttore del Dipartimento di Psicologia – Prof. Vincenzo Natale – Viale Berti Pichat 5, Bologna e il Direttore del Dipartimento di Scienze per la Qualità della Vita – Prof. Giovanni Matteucci – Corso d'Augusto 237, Rimini. Il coordinatore del progetto è la Prof.ssa Alessia Tessari (alessia.tessari@unibo.it).

4. **Diritti dell'interessato**

Le persone a cui si riferiscono i dati hanno il diritto in qualunque momento di ottenere la conferma dell'esistenza o meno dei medesimi, di conoscerne il contenuto e l'origine, verificarne l'esattezza, chiederne l'integrazione o l'aggiornamento, oppure la rettificazione (articolo 7 del Codice in materia di protezione dei dati personali). Ai sensi del medesimo articolo hanno il diritto di chiedere la cancellazione, la trasformazione in forma anonima o il blocco dei dati trattati in violazione di legge, nonché di opporsi in ogni caso, per motivi legittimi, al loro trattamento. Le richieste vanno rivolte ai Responsabili sopra indicati.

Letta l'informativa, il/la sottoscritto/a ____

☐ acconsente ☐ non acconsente
al trattamento dei suoi dati per fini di ricerca statistica e scientifica

Data _____________ Firma_________________________________

Figure A.4: Privacy form for adults

Modulo Informativo per la partecipazione – Consenso Informato

1. **IL COLLEGAMENTO TRA LE PERFOMANCE SPORTIVE E LE CAPACITA' DECISIONALI DEI GIOVANI ATLETI IN DOMINI NON SPORTIVI - responsabili Prof.ssa Tessari**

Gentile Signora/Signore,

Suo figlia/o è invitata/o a prendere parte a una ricerca condotta nel quadro del progetto "Il collegamento tra le performance sportive e le capacità decisionali dei giovan atleti in domini non sportivi" di cui è responsabile la Prof.ssa Alessia Tessari. Prima di decidere se partecipare è importante che abbia tutte le informazioni necessarie per aderire in modo consapevole e responsabile. Le chiediamo di leggere questo documento e di fare a chi le ha proposto questo studio tutte le domande che ritiene opportune.

2. **Breve descrizione e Obiettivi**

Il progetto di ricerca ha come obiettivo quello di studiare il collegamento tra attività sportiva e capacità decisionali in contesti non-sportivi. Per raggiungere questo obiettivo, i ricercatori impegnati nel progetto si propongono di raccogliere e analizzare, attraverso un compito cognitivo-intellettivo ed uno decisionale, una serie di dati che permetteranno di valutare tali capacità. Prima di iniziare Le verrà chiesto di compilare alcuni questionari.

3. **Cosa comporta la partecipazione allo studio?**

La partecipazione al progetto di ricerca comporta il completamento di due questionari denominati State Questionario ansia di tratto e stato - STAI (Spielberger, 1982), Questionario di Personalità BFQ-C (John & Srivastava) i quali permetteranno di identificare alcuni aspetti psicologici di vostro foglio. La durata prevista del completamento dei questionari è di circa 10 minuti. Successivamente verrà fatto accomodare davanti ad un computer nel quale verranno presentati due compiti. Il primo compito è un compito relativo alle capacità cognitive (durata ca. 30 min), mentre il secondo riguarda un compito decisionale (durata ca. 15 min) in cui dovrà valutare ogni risposta che intende prendere.

4. **Benefici, disagi e/o rischi potenziali della partecipazione**

La partecipazione allo studio è volontaria e gratuita. Per i partecipanti la collaborazione non comporta nessun tipo di rischio o disagio e non sarà eseguita alcun tipo di diagnosi.

5. **Ritiro dallo studio**

Lei, in quanto genitore, ha il diritto di ritirare in qualsiasi momento il consenso alla partecipazione a questo studio, anche senza preavviso o motivazione specifica.

6. **Restituzione**

Lei ha diritto a richiedere informazioni sui risultati e sull'esito della ricerca.

7. **Misure previste per tutelare l'anonimato**

L'elaborazione dei dati raccolti sarà condotta in modo da eliminare qualsiasi riferimento che possa permettere di ricollegare singole affermazioni ad una determinata persona. I risultati della ricerca saranno pubblicati in forma riassuntiva e in nessun caso eventuali brevi citazioni saranno riconducibili a singole persone.

8. **Contatti**

Per qualsiasi informazione e chiarimento su questo studio o per qualsiasi necessità può rivolgersi al dottorando Gabriele Russo (gabriele.russo5@unibo.it) che è a sua disposizione per ulteriori informazioni o chiarimenti.

Consenso informato alla partecipazione allo studio

Il/la sottoscritto/a ____________ residente in __________, via ______
DICHIARA

☐ di aver letto il suddetto foglio informativo ricevuto, di aver compreso sia le informazioni in esso contenute sia le informazioni fornite in forma orale dal personale addetto al progetto di ricerca "……" e di aver avuto ampio tempo ed opportunità di porre domande ed ottenere risposte soddisfacenti dal personale addetto;

☐ di aver compreso che la partecipazione allo studio è del tutto volontaria e libera, che ci si potrà ritirare dallo studio in qualsiasi momento, senza dover dare spiegazioni e senza che ciò comporti alcuno svantaggio o pregiudizio;

☐ di aver compreso la natura e le attività che la partecipazione allo studio comportano e i relativi rischi;

☐ di aver compreso che la partecipazione a questo studio non comporterà il riconoscimento di alcun vantaggio di natura economica diretto o indiretto.

Conseguentemente, il/la sottoscritto/a
0 ACCONSENTE 0 NON ACCONSENTE

A che sua/o figlia/o partecipi allo studio, nella consapevolezza che tale consenso è manifestato liberamente ed è revocabile in ogni momento senza che ciò comporti alcuno svantaggio o pregiudizio.

_________________, __________________
(luogo e data)

____
(firma di chi esercita la responsabilità genitoriale)

Il/la sottoscritto/a ____________ residente in __________, via ______
DICHIARA

☐ di aver letto il suddetto foglio informativo ricevuto, di aver compreso sia le informazioni in esso contenute sia le informazioni fornite in forma orale dal personale addetto al progetto di ricerca "……" e di aver avuto ampio tempo ed opportunità di porre domande ed ottenere risposte soddisfacenti dal personale addetto;

☐ di aver compreso che la partecipazione allo studio è del tutto volontaria e libera, che ci si potrà ritirare dallo studio in qualsiasi momento, senza dover dare spiegazioni e senza che ciò comporti alcuno svantaggio o pregiudizio;

☐ di aver compreso la natura e le attività che la partecipazione allo studio comportano e i relativi rischi;

☐ di aver compreso che la partecipazione a questo studio non comporterà il riconoscimento di alcun vantaggio di natura economica diretto o indiretto.

Conseguentemente, il/la sottoscritto/a
0 ACCONSENTE 0 NON ACCONSENTE

A che sua/o figlia/o partecipi allo studio, nella consapevolezza che tale consenso è manifestato liberamente ed è revocabile in ogni momento senza che ciò comporti alcuno svantaggio o pregiudizio.

_________________, __________________
(luogo e data)

____
(firma di chi esercita la responsabilità genitoriale)

____
(firma di chi raccoglie il consenso)

Figure A.5: Informed Consent for young people

Modulo Informativo per il trattamento dei dati

Informativa sulla protezione dei dati personali (ex artt. 12, 13 e 14 Regolamento 2016/679)

Ai sensi dell'art. 13 del D.lgs. 196/2003, si nforma che l'Alma Mater Studiorum - Università di Bologna procederà al trattamento dei dati forniti esclusivamente per fini istituzionali (art. 4 del D.R. 271/2009) e nel rispetto della normativa in materia di protezione dei dati personali.

1. **Finalità dei dati**

I dati saranno trattati, anche con l'ausilio di mezzi elettronici, per finalità di ricerca scientifica, nell'ambito del progetto di ricerca intitolato " **IL COLLEGAMENTO TRA LE PERFOMANCE SPORTIVE E LE CAPACITA' DECISIONALI DEGLI ATLETI IN DOMINI NON SPORTIVI - responsabile Prof.ssa Tessari**".
La ricerca è finalizzata allo studio delle capacità decisionali in contesti non sportivi. Per fare ciò, verranno registrati i tempi di risposta e le risposte dei partecipanti ad un test cognitivo e ad uno decisionale. Le risposte al test saranno raccolte in un'unica sessione sperimentale.

2. **Modalità di trattamento, conservazione e diffusione dei dati**

I dati verranno raccolti e conservati in modo che l'identificazione della persona sia prevenuta con i mezzi tecnologici disponibili, come ad esempi password crittografate. Il trattamento però si avvarrà di un codice che le sarà assegnato al momento del coinvolgimento e che servirà ad identificare il soggetto con i dati registrati. Per tale ragione si renderà necessario conservare l'associazione codice/utente fino al termine della ricerca (~A.A. 2019/20). La conservazione dei codici associativi avverrà tramite modalità protette da password crittografate. Si precisa che nessun ricercatore potrà mai elaborare i risultati con lo scopo di identificare i partecipanti e diffondere la loro identità. I dati, infatti, verranno sempre analizzati in forma collettiva, con l'obiettivo di estrarre i risultati emersi. Si precisa in fine che, per nessun motivo, saranno forniti i dati identificativi a persone terze.

3. **Soggetti del trattamento**

Il Titolare del trattamento è l'Alma Mater Studiorum - Università di Bologna – Via Zamboni, 33 40126 Bologna (BO). I Responsabili del trattamento sono il Direttore del Dipartimento di Psicologia – Prof. Vincenzo Natale – Viale Berti Pichat 5, Bologna e il Direttore del Dipartimento di Scienze per la Qualità della Vita – Prof. Giovanni Matteucci – Corso d'Augusto 237, Rimini. Il coordinatore del progetto è la Prof.ssa Alessia Tessari (alessia.tessari@unibo.it).

4. **Diritti dell'interessato**

Le persone a cui si riferiscono i dati hanno il diritto in qualunque momento di ottenere la conferma dell'esistenza o meno dei medesimi, di conoscerne il contenuto e l'origine, verificarne l'esattezza, chiederne l'integrazione o l'aggiornamento, oppure la rettificazione (articolo 7 del Codice in materia di protezione dei dati personali). Ai sensi del medesimo articolo hanno il diritto di chiedere la cancellazione, la trasformazione in forma anonima o il blocco dei dati trattati in violazione di legge, nonché di opporsi in ogni caso, per motivi legittimi, al loro trattamento. Le richieste vanno rivolte ai Responsabili sopra indicati.

Letta l'informativa, il/la sottoscritto/a ____

☐ acconsente ☐ non acconsente
al trattamento dei suoi dati per fini di ricerca statistica e scientifica

Data _____________ Firma__________________________________

Figure A.6: Privacy form for young people

Bibliography

Abernethy, B. (1996). Training the Visual-Perceptual Skills of Athletes: Insights from the Study of Motor Expertise. *The American Journal of Sports Medicine*, 24(6_suppl):S89–S92.

Abernethy, B., Zawi, K., and Jackson, R. C. (2008). Expertise and attunement to kinematic constraints. *Perception*, 37(6):931–948.

Aglioti, S. M., Cesari, P., Romani, M., and Urgesi, C. (2008). Action anticipation and motor resonance in elite basketball players. *Nature Neuroscience*.

Alder, D., Ford, P. R., Causer, J., and Williams, A. M. (2014). The coupling between gaze behavior and opponent kinematics during anticipation of badminton shots. *Human Movement Science*.

Bang, D. and Fleming, S. M. (2018). Distinct encoding of decision confidence in human medial prefrontal cortex. *Proceedings of the National Academy of Sciences*, 115(23):6082–6087.

Bates, D., Mächler, M., Bolker, B., and Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1):1–48.

Bechara, A., Damasio, H., Tranel, D., and Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science*, 275(5304):1293–1295.

Berger, J. O. (1989). *Statistical Decision Theory*, pages 217–224. Palgrave Macmillan UK, London.

Berger, J. O. (1990). Statistical decision theory. In *Time Series and Statistics*, pages 277–284. Springer.

Biddle, S. J. and Asare, M. (2011). Physical activity and mental health in children and adolescents: A review of reviews. *British Journal of Sports Medicine*, 45(11):886–895.

Biddle, S. J., Ciaccioni, S., Thomas, G., and Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise*, 42(May):146–155.

Byrne, K. A., Silasi-Mansat, C. D., and Worthy, D. A. (2015). Who chokes under pressure? The Big Five personality traits and decision-making under pressure. *Personality and Individual Differences*, 74:22–28.

Catrambone, R. and Holyoak, K. J. (1989). Overcoming Contextual Limitations on Problem-Solving Transfer. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15(6):1147–1156.

Causer, J., Barach, P., and Williams, A. M. (2014). Expertise in medicine: Using the expert performance approach to improve simulation training. *Medical Education*.

Causer, J., Mcrobert, A. P., and Williams, A. M. (2013). The effect of stimulus intensity on response time and accuracy in dynamic, temporally constrained environments. *Scandinavian Journal of Medicine and Science in Sports*, 23(5):627–634.

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences*, 36(3):181–204.

Clifford, C. W. G., Arabzadeh, E., and Harris, J. A. (2008). Getting technical about awareness. *Trends in Cognitive Sciences*, 12(2):54–58.

Corbetta, M. and Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience*, 3(3):201–215.

de Greeff, J. W., Bosker, R. J., Oosterlaan, J., Visscher, C., and Hartman, E. (2018). Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis. *Journal of Science and Medicine in Sport*, 21(5):501–507.

Del Missier, F., Mäntylä, T., and de Bruin, W. B. (2012). Decision-making competence, executive functioning, and general cognitive abilities. *Journal of Behavioral Decision Making*, 25(4):331–351.

Derakshan, N. and Eysenck, M. W. (2009). Anxiety, processing efficiency, and cognitive performance: New developments from attentional control theory. *European Psychologist*, 14(2):168–176.

Edwards, W. (1954). The theory of decision making. *Psychological Bulletin*, 51(4):380–417.

Engle, R. W., Laughlin, J. E., Tuholski, S. W., and Conway, A. R. (1999). Working memory, short-term memory, and general fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General*, 128(3):309–331.

Eysenck, H. J. and Eysenck, S. B. G. (1994). *Manual of the Eysenck personality questionnaire:(EPQ-R adult)*. EdITS/Educational and Industrial Testing Service.

Eysenck, M. W. and Calvo, M. G. (1992). Anxiety and Performance: The Processing Efficiency Theory. *Cognition & Emotion*, 6(6):409–434.

Eysenck, M. W., Derakshan, N., Santos, R., and Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory.

Goldstone, R. L. and Sakamoto, Y. (2003). The transfer of abstract principles governing complex adaptive systems. *Cognitive Psychology*, 46(4):414–466.

Gonzaga, A. D. S., Albuquerque, M. R., Malloy-Diniz, L. F., Greco, P. J., and Teoldo Da Costa, I. (2014). Affective decision-making and tactical behavior of under-15 soccer players. *PLoS ONE*, 9(6):1–6.

Gonzalez, C., Thomas, R. P., and Vanyukov, P. (2005). The relationships between cognitive ability and dynamic decision making. *Intelligence*, 33(2):169 – 186.

Gu, Q., Zou, L., Loprinzi, P. D., Quan, M., and Huang, T. (2019). Effects of open versus closed skill exercise on cognitive function: A systematic review. *Frontiers in Psychology*, 10(JULY).

Hagemann, N., Strauss, B., and Büsch, D. (2008). The complex problem-solving competence of team coaches. *Psychology of Sport and Exercise*, 9(3):301–317.

Hamel, R. and Schmittmann, V. D. (2006). The 20-minute version as a predictor of the raven advanced progressive matrices test. *Educational and Psychological Measurement*, 66(6):1039–1046.

Hartley, C. A. and Phelps, E. A. (2012). Anxiety and decision-making. *Biological Psychiatry*, 72(2):113–118.

Hötting, K. and Röder, B. (2013). Beneficial effects of physical exercise on neuroplasticity and cognition. *Neuroscience and Biobehavioral Reviews*, 37(9):2243–2257.

Janssen, I. and Leblanc, A. G. (2010). Open Access REVIEW Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 7.

Kahneman, D. and Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, 47(2):263.

Kayhan, E., Hunnius, S., O'Reilly, J. X., and Bekkering, H. (2019). Infants differentially update their internal models of a dynamic environment. *Cognition*, 186(February):139–146.

Kepecs, A. and Mainen, Z. F. (2012). A computational framework for the study of confidence in humans and animals. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 367(1594):1322–1337.

Kepecs, A., Uchida, N., Zariwala, H. A., and Mainen, Z. F. (2008). Neural correlates, computation and behavioural impact of decision confidence. *Nature*, 455:227 EP –.

Khalil, R. (2016). Influence of extroversion and introversion on decision making ability. *International Journal of Research in Medical Sciences*, (May):1534–1538.

Kleiner, M., Brainard, D., Pelli, D., Ingling, A., Murray, R., and Broussard, C. (2007). What's new in psychtoolbox-3. *Perception*, 36(14):1–16.

Krassanakis, V., Filippakopoulou, V., and Nakos, B. (2014). Eyemmv toolbox: An eye movement post-analysis tool based on a two-step spatial dispersion threshold for fixation identification. *Journal of Eye Movement Research*, 7(1).

Larsen, T. and Coricelli, G. (2017). Transfer of confidence in a novel observational learning task. page 20.

Lauriola, M. and Levin, I. P. (2001). Personality traits and risky decision-making in a controlled experimental task: An exploratory study. *Personality and Individual Differences*, 31(2):215–226.

Lejuez, C. W., Richards, J. B., Read, J. P., Kahler, C. W., Ramsey, S. E., Stuart, G. L., Strong, D. R., and Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: The balloon analogue risk task (BART). *Journal of Experimental Psychology: Applied*, 8(2):75–84.

Lenth, R., Singmann, H., Love, J., Buerkner, P., and Herve, M. (2018). Emmeans: Estimated marginal means, aka least-squares means. *R package version*, 1(1):3.

Mann, D. Y., Williams, A. M., Ward, P., and Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport and Exercise Psychology*, 29(4):457–478.

Martens, R., Burton, D., Vealey, R. S., Bump, L. A., and Smith, D. E. (1990). Development and validation of the competitive state anxiety inventory-2. *Competitive anxiety in sport*, pages 117–190.

MATLAB (2018). *R2018a)*. The MathWorks Inc., Natick, Massachusetts.

Memmert, D., Simons, D. J., and Grimme, T. (2009). The relationship between visual attention and expertise in sports. *Psychology of Sport and Exercise*, 10(1):146–151.

Miceli, S., de Palo, V., Monacis, L., Di Nuovo, S., and Sinatra, M. (2018). Do personality traits and self-regulatory processes affect decision-making tendencies? *Australian Journal of Psychology*, 70(3):284–293.

Mohanty, A. and Sussman, T. J. (2013). Top-down modulation of attention by emotion. *Frontiers in Human Neuroscience*, (MAR).

Nassar, M. R., Bruckner, R., Gold, J. I., Li, S. C., Heekeren, H. R., and Eppinger, B. (2016). Age differences in learning emerge from an insufficient representation of uncertainty in older adults. *Nature Communications*, 7(May 2015).

O'Reilly, J. X., Schüffelgen, U., Cuell, S. F., Behrens, T. E. J., Mars, R. B., and Rushworth, M. F. S. (2013). Dissociable effects of surprise and model update in parietal and anterior cingulate cortex. *Proceedings of the National Academy of Sciences*, 110(38):E3660–E3669.

Oudejans, R. R. and Pijpers, J. R. (2010). Training with mild anxiety may prevent choking under higher levels of anxiety. *Psychology of Sport and Exercise*, 11(1):44–50.

Paluska, S. A. and Schwenk, T. L. (2000). Physical activity and mental health: Current concepts. *Sports Medicine*, 29(3):167–180.

Persaud, N., McLeod, P., and Cowey, A. (2007). Post-decision wagering objectively measures awareness. *Nature Neuroscience*, 10(2):257–261.

Pesce, C. and Bosel, R. (2001). Focusing of visuospatial attention - Electrophysiological evidence from subjects with and without attentional expertise. *Journal of Psychophysiology*, 15(4):256–274.

Pesce, C., Crova, C., Cereatti, L., Casella, R., and Bellucci, M. (2009). Physical activity and mental performance in preadolescents: Effects of acute exercise on free-recall memory. *Mental Health and Physical Activity*, 2(1):16–22.

Pesce Anzeneder, C., Boesel, R., Kortmann, O., and Muecke, M. (1998). Focussing of visual attention of high performance volley-ball players. *LEISTUNGSSPORT*, 28:35–41.

R Core Team (2013). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

Raab, M. (2007). Think SMART, not hard - a review of teaching decision making in sport from an ecological rationality perspective. *Physical Education Sport Pedagogy*, 12(1):1–22.

Rainieri, G., Fraboni, F., Russo, G., Tul, M., Pingitore, A., Tessari, A., and Pietrantoni, L. (2020a). Visual scanning techniques and mental workload of helicopter pilots during simulated flight. *Aerospace Medicine and Human Performance*, 92(1):11–19.

Rainieri, G., Fraboni, F., Tušl, M., Russo, G., Giusino, D., De Angelis, M., Tria, A., and Pietrantoni, L. (2020b). Workload and Visual Scanning Techniques of Expert and Novice Helicopter Pilots During Simulated Flight in Open Sea. In Ahram, T., Taiar, R., Gremeaux-Bader, V., and Aminian, K., editors, *Advances in Intelligent Systems and Computing*, volume 1152 AISC, pages 39–44, Cham. Springer International Publishing.

Raven, J. Court, j. & raven, j.(1990) manual for coloured progressive matrices: Section 2.

Raven, J. C. (1958). *Guide to using the Coloured Progressive Matrices.* H. K. Lewis & Co., Oxford, England.

Raven, J. C. and Court, J. H. (1998). *Raven's progressive matrices and vocabulary scales*. Oxford pyschologists Press.

Robazza, C. and Bortoli, L. (2003). Intensity, idiosyncratic content and functional impact of performance-related emotions in athletes. *Journal of Sports Sciences*, 21(3):171–189.

Roca, A. and Williams, A. M. (2017). Does decision making transfer across similar and dissimilar sports? *Psychology of Sport and Exercise*, 31:40–43.

Roca, A., Williams, A. M., and Ford, P. R. (2012). Developmental activities and the acquisition of superior anticipation and decision making in soccer players. *Journal of Sports Sciences*, 30(15):1643–1652.

RStudio Team (2015). *RStudio: Integrated Development Environment for R*. RStudio, Inc., Boston, MA.

Russo, G. and Ottoboni, G. (2019). The perceptual – Cognitive skills of combat sports athletes: A systematic review.

Scharfen, H. E. and Memmert, D. (2019). Measurement of cognitive functions in experts and elite athletes: A meta-analytic review. *Applied Cognitive Psychology*, 33(5):843–860.

Slovic, P., Fischhoff, B., and Lichtenstein, S. (1977). Behavioral Decision Theory. *Annual Review of Psychology*, 28(1):1–39.

Spielberger, C. D. (1983). Manual for the state-trait anxiety inventory stai (form y)(" self-evaluation questionnaire").

Stuart, S., Hickey, A., Vitorio, R., Welman, K., Foo, S., Keen, D., and Godfrey, A. (2019). Eye-tracker algorithms to detect saccades during static and dynamic tasks: a structured review. *Physiological Measurement*, 40(2):02TR01.

Stupple, E. J., Ball, L. J., Evans, J. S. B., and Kamal-Smith, E. (2011). When logic and belief collide: Individual differences in reasoning times support a selective processing model. *Journal of Cognitive Psychology*, 23(8):931–941.

Tao, Y., Cai, Y., Rana, C., and Zhong, Y. (2020). The impact of the Extraversion-Introversion personality traits and emotions in a moral decision-making task. *Personality and Individual Differences*, 158(March 2019).

Taylor, A. H., Cable, N. T., Faulkner, G., Hillsdon, M., Narici, M., and Van der Bij, A. K. (2004). Physical activity and older adults: A review of health benefits and the effectiveness of interventions. *Journal of Sports Sciences*, 22(8):703–725.

Trippas, D., Kellen, D., Singmann, H., Pennycook, G., Koehler, D. J., Fugelsang, J. A., and Dubé, C. (2018). Characterizing belief bias in syllogistic reasoning: A hierarchical bayesian meta-analysis of roc data. *Psychonomic bulletin & review*, 25(6):2141–2174.

Vaghi, M. M., Luyckx, F., Sule, A., Fineberg, N. A., Robbins, T. W., and

De Martino, B. (2017). Compulsivity reveals a novel dissociation between action and confidence. *Neuron*, 96(2):348–354.

Vater, C., Roca, A., and Williams, A. M. (2016). Effects of anxiety on anticipation and visual search in dynamic, time-constrained situations. *Sport, Exercise, and Performance Psychology*, 5(3):179–192.

Vickers, J. N. and Williams, A. M. (2007). Performing under pressure: The effects of physiological arousal, cognitive anxiety, and gaze control in biathlon. *Journal of Motor Behavior*, 39(5):381–394.

Voss, M. W., Kramer, A. F., Basak, C., Prakash, R. S., and Roberts, B. (2010). Are expert athletes 'expert' in the cognitive laboratory? A meta-analytic review of cognition and sport expertise. *Applied Cognitive Psychology*, 24(6):812–826.

Vostroknutov, A., Polonio, L., and Coricelli, G. (2018). The role of intelligence in social learning. *Scientific Reports*, 8(1):6896.

Wagner, J. F. (2006). Transfer in pieces. *Cognition and Instruction*, 24(1):1–71.

Ward, P., Farrow, D., Harris, K. R., Williams, A. M., Eccles, D. W., and Ericsson, K. A. (2008). Training perceptual-cognitive skills: Can sport psychology research inform military decision training? *Military Psychology*, 20(SUPPL. 1):71–103.

Williams, A. M. (2009). Perceiving the intentions of others: how do skilled performers make anticipation judgments? In *Progress in Brain Research*, volume 174, pages 73–83.

Williams, A. M. and Elliott, D. (1999). Anxiety, Expertise, and Visual Search Strategy in Karate. *Journal of Sport and Exercise Psychology*, 21(4):362–375.

Williams, A. M. and Ericsson, K. A. (2005). Perceptual-cognitive expertise in sport: Some considerations when applying the expert performance approach. *Human Movement Science*, 24(3):283–307.

Yeung, N. and Summerfield, C. (2012). Metacognition in human decision-making: confidence and error monitoring. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 367(1594):1310–1321.

Zhu, H., Pi, Y. L., Qiu, F. H., Wang, F. J., Liu, K., Ni, Z., Wu, Y., and Zhang, J. (2019). Visual and Action-control Expressway Associated with Efficient Information Transmission in Elite Athletes. *Neuroscience*, 404:353–370.

Zhu, N., Jacobs, D. R., Schreiner, P. J., Yaffe, K., Bryan, N., Launer, L. J., Whitmer, R. A., Sidney, S., Demerath, E., Thomas, W., Bouchard, C., He, K., Reis, J., and Sternfeld, B. (2014). Cardiorespiratory fitness and cognitive function in middle age: The CARDIA Study. *Neurology*, 82(15):1339–1346.

Zijlstra, F. (1993). Subjective rating scale mental effort, dutch.