Individual and Cultural Differences in Attentional Learning

Sue Lynn Mah BSc (Hons)

Thesis submitted to the University of Nottingham for the Degree of Doctor of Philosophy

December 2021

Abstract

Associative learning phenomena have been widely used to understand the deficits in selective attention in schizophrenia by using the personality trait, schizotypy, as a proxy. However, other personality traits such as anxiety and the Big 5 personality traits have been under-looked despite a comorbidity between schizophrenia/schizotypy and anxiety as well as the psychopathology links of the Big 5 traits. Moreover, there is evidence of different thinking styles exhibited by different cultures (e.g., individualistic and collectivistic cultures), where the majority of members in an individualistic culture learn and think in an analytical/elemental manner while the majority of members in a collectivistic culture have a predisposition to think and learn holistically/configurally. It is therefore proposed that other personality traits and cultural differences in thinking/learning can explain conflicting evidence found in the schizotypy and associative learning literature.

Previous studies of variations in attention-driven associative learning have demonstrated an emphasis on latent inhibition and less so on blocking and learned predictiveness. Furthermore, there are very few studies that have attempted to reproduce two learning effects within the same individual. Therefore, Study 1 aimed to create a paradigm which can generate the effects of blocking and learned predictiveness within the same participant to first, fill the gap in the literature, and second, to develop a better, converging, understanding of the role of attention in learning. The results of this study found an effect of learned predictiveness but no effect of blocking. It was proposed that the effect of learned predictiveness somehow masked the effect of blocking, so Study 2 aimed to replicate the previous study but with only the blocking trials. The results still showed no blocking effect despite the removal of the learned predictiveness trials. There was a possibility that a within-compound association effect was the reason why blocking was not found. Therefore,

in Study 3, the design of Study 2 was replicated but now with an addition of a Stage 3 where the blocked stimuli's contingencies were switched, and if there really was a within-compound association, the ratings for these blocked stimuli would be reduced compared to the first test stage. The results showed at test stage 1, the ratings for the control stimuli were lower than the blocked stimuli, replicating results of Study 2. At test stage 2, with a change in contingency from Stage 3, the ratings for the blocked stimuli were reduced but it was still higher than the control stimuli, suggesting a within-compound association. Study 4 aimed to use a simpler blocking design (Kamin, 1969) to determine if the previous design used was too complicated. While there the ratings for the control stimuli were higher than the blocked stimuli, a paired samples t-test revealed no significance. The results from Studies 1-4 can be explained using acquired distinctiveness/acquired equivalence theories and the redundancy effect.

Since attempts to demonstrate a blocking effect throughout Study 1 to 4 failed, Study 5 aimed to generate the effects of latent inhibition and learned predictiveness using a letter prediction task (Granger et al., 2016) and a food allergist task (Le Pelley and McLaren, 2003). Personality traits including the Big 5, schizotypy and anxiety were also measured. The participants were divided into individualistic and collectivistic groups using Hofstede's database which sorts individuals via their nationalities. The results initially showed that participants, overall, exhibited both latent inhibition and learned predictiveness. When split by culture, only participants from the individualistic group showed both effects while participants from the collectivistic group showed only latent inhibition. There was also no correlation between latent inhibition and learned predictiveness overall and within groups. Moreover, there was an effect of impulsive nonconformity that was related to a greater magnitude of latent inhibition in the individualistic group. It was also found that participants high in conscientiousness from the individualistic group learned more about the relevant stimuli in the learned predictiveness task but participants from the collectivistic group learned about the relevant stimuli less. There was no evidence of anxiety predicting latent inhibition or learned predictiveness.

Since Study 5 was exploratory by nature, Study 6 aimed to replicate the findings but specifically focussing on the relationship between personality traits and culture in latent inhibition. It could be seen from the results of this current study that latent inhibition was observed in both the individualistic and collectivistic group, replicating Study 5. This study was also conducted online due to Covid-19 and the results demonstrated that there was no difference in response times between the lab-based task and this online version. The effect of impulsive nonconformity predicting enhanced latent inhibition in participants from the individualistic group found in Study 5 was not replicated. Instead, it was revealed that conscientiousness predicted latent inhibition in the individualistic group and openness predicted latent inhibition in the collectivistic group. There was again no evidence of anxiety being related to the magnitude of latent inhibition.

Study 7 was a replication of Study 5, but specifically investigating the relationship between the Big 5, schizotypy and cultural orientation and learned predictiveness. Since there were limitations to sorting participants into individualistic and collectivistic groups with their nationalities (Cohen, 2009; Kitayama and Uskul, 2011; Maisuwong, 2012), a cultural orientation questionnaire (Sharma, 2010) was employed to provide a more accurate measure of trait individualism and collectivism to provide further validity to the results found. The results showed a learned predictiveness effect in the individualistic group but not the collectivistic group, replicating results from Study 5. The effect of conscientiousness predicting the learning of relevant stimuli was not replicated but an effect of extraversion positively predicting the learning of irrelevant stimuli was found within the collectivistic group. There was also an effect of introvertive anhedonia negatively predicting the learning of irrelevant stimuli in the collectivistic group.

The final chapter of this thesis begins with a summary of results from all the studies. It then discusses how the individual and cultural differences exhibited by participants influenced the results throughout Studies 1-7 and provides suggestions as to why evidence from previous literature was not always consistent. The strengths and limitations faced in this thesis are discussed and suggestions for future research described.

Acknowledgements

I would like to firstly thank my parents, especially my mum, who without their support, I really would not be able to move halfway across the world and do a PhD. I would also want to take this opportunity to give a shoutout to my grandmother who is basically the reason why I chose psychology. It just a bit of a shame that she could not see my graduate again and 戴四方帽.

I would also really like to thank my supervisor Mark for always having an open-door policy and allowing me to drop by for questions, random crazy idea chats or if I just need to rant and cry. And I really do appreciate it when you explain random British culture to me because even though I did not have a language barrier, the culture can still get rather confusing. Also, I'm super grateful that you were still super reachable during the lockdown and I would never forget that you sent me groceries when I needed to self-isolate. PhD-ing during a global pandemic is super weird right?

I would also like to thank my second supervisor Paula. We may not meet as often, but I really appreciate that I can always go to you for a chat or rant. And to Jess, thanks for supervising me when I was back in Malaysia. I really am grateful that you helped me sort out the details and how to pay participants and hopefully, the people were not too annoying.

And now my friends…

Chris, thanks for being my friend since Malaysia :) If it were not for you, I would not have easily made the decision to apply to do a PhD in Nottingham. Thanks for letting me rant about PhD and life in general and help me out when the stats got confusing or I am just generally feeling dumb.

To the Gloaftinous group (I feel really bad naming you guys in sequence because it may seem like I treasure one of you more than the other so I shall just use our group chat name), I could not think of a better group of people to spend the lockdown with. Probably because the context of us meeting each other was by sharing the same house, you guys really made me feel like I have a home here in the UK, so really thank you!

And a special shoutout to Luke. Thanks for being so kind and helping me out whenever I'm in difficult situations. And finally, a big thank you to Cath for always lending me an ear whenever anything and everything got too stressful. Without you, I probably would not be completing this PhD with my sanity still in check.

Table of Contents

<u>Chapter 1: Learning and Attention</u> **25**

1.1: Overview 26

1.2: Introduction 26

1.3: Overshadowing and Blocking 27

1.4: The Rescorla-Wagner (1972) Model 30

1.5: Conditioned Inhibition 32

1.6: Latent Inhibition 33

1.7: The Mackintosh (1975) Theory 35

1.8: Intradimensional/Extradimensional Shift 36

1.9: Learned Predictiveness 38

1.10: The Pearce-Hall (1980) Model 43

1.11: Hybrid Models 47

1.12: Summary of Chapter 50

<u>Chapter 2: Individual and Cultural Differences in Learning and Attention</u> **52**

2.1: Overview 53

2.2: The Big 5 54

2.3: Links to psychopathology 55

2.3.i: Schizophrenia 56

2.3.ii: Comorbidity of schizophrenia and anxiety 58

2.4: Difficulties researching psychopathology 59

2.4.i: Dimensional approach of schizotypy 60

2.4.ii: Schizotypy and anxiety 61

2.4.iii: Schizotypy, anxiety and the Big 5 62

2.5: Relationship between schizotypy and associative learning 63

2.5.i. Latent Inhibition 63

2.5.ii: Blocking 65

2.5.iii: Learned Predictiveness 66

2.5.iv: Summary 66

2.6: Relationship between anxiety and associative learning 67

2.6.i: Latent Inhibition 67

2.6.ii: Blocking 68

2.7: Relationships between the Big 5 and learning 69

2.7.i: Wisconsin Card Sorting Task (WCST) 70

2.7.ii: Summary 72

2.8: Cultural differences in learning 73

2.8.i: Definition of culture 73

2.8.ii: Individualism and Collectivism 74

2.8.iii: Empirical evidence 76

2.9: Rationale and Aims 79

Chapter 3: Blocking and Learned Predictiveness **83**

3.1: Study 1: Pilot 84

3.1.i: Introduction 84

3.1.ii: Methods 89

3.1.ii.a. Design 89

3.1.ii.b. Participants 90

3.1.ii.c. Apparatus 91

3.1.ii.d. Materials 91

3.1.ii.e. Procedure 92

3.1.iii: Results 97

3.1.iii.a: Data treatment 97

3.1.iii.b: Analysis 98

3.1.iv: Discussion 102

3.2: Study 2: Blocking 103

3.2.i: Introduction 103

3.2.ii: Methods 105

3.2.ii.a. Design 105

3.2.ii.b. Participants 105

3.2.iii: Results 105

3.2.iii.a: Analysis 105

3.2.iv: Discussion 108

3.3: Study 3: Blocking and Within-Compound Association 109

3.3.i: Introduction 109

3.3.ii: Methods 111

3.3.ii.a. Design 111

3.3.ii.b. Participants 111

3.3.ii.c. Procedure 111

3.3.iii: Results 112

3.3.iii.a: Analysis 112

3.3.iv: Discussion 117

3.4: Study 4: Kamin Blocking 118

3.4.i: Introduction 118

3.4.ii: Methods 118

3.4.ii.a. Design 118

3.4.ii.b. Participants 119

3.4.ii.c. Procedure 119

3.4.iii: Results 119

3.4.iii.a: Analysis 119

3.4.iv: Discussion 122

3.5: General Discussion 122

Chapter 4: Study 5: Relationship between personality traits and cultural orientation in latent inhibition and learned predictiveness 130

4.1: Introduction 131

4.2: Methods 136

4.2.i: Design 136

4.2.ii: Participants 137

4.2.iii: Apparatus 138

4.2.iv: Materials 138

4.2.v: Procedure 140

4.2.v.a: Latent Inhibition (Letter Prediction Task) 140

4.2.v.b: Learned Predictiveness (Food Allergist Task) 143

4.2.v.c: Questionnaires 146

4.3: Results 147

Part A: Data treatment 147

A1: Behavioural data 148

A2: Psychometric data 149

Part B: Analysis of behavioural data 151

B1: Latent inhibition 151

B2: Cultural differences in latent inhibition 152

B3: Learned predictiveness 154

B4: Cultural differences in learned predictiveness 156

B5: Relationship between latent inhibition and learned predictiveness 161

B6: Summary of findings 164

Part C: Effects of personality traits on latent inhibition 164

C1: Schizotypy 164

C1.i: Further analysis: Simple moderation analysis 168

C2: Anxiety 170

C3: The Big 5 171

C4: Summary of findings 171

Part D: Effects of personality traits on learned predictiveness 172

D1: Schizotypy 172

D2: Anxiety 175

D3: The Big 5 175

D3.i: Further analysis: Simple moderation analysis 179

D4: Summary of findings 181

4.4: General Discussion 182

4.4.i: Latent Inhibition and Learned Predictiveness 182

4.4.ii: Cultural differences in latent inhibition and learned predictiveness 183

4.4.iii: Individual differences in latent inhibition 186

4.4.iv: Individual differences in learned predictiveness 187

4.4.v: Conclusion 189

Chapter 5: Study 6: Relationship between personality traits and cultural orientation in latent inhibition- An online replication **191**

5.1: Introduction 192

5.2: Methods 193

4.2.i: Participants 193

4.2.ii: Procedure 194

5.3: Results 195

Part A: Data treatment 195

Part B1: Analysis of behavioural data 196

B2: Cultural differences in latent inhibition 198

B3: Differences between lab-based and online experiments 200

B4: Summary of findings 201

Part C: Effects of personality traits on latent inhibition 201

C1: Schizotypy 201

C2: Anxiety 202

C3: The Big 5 203

C4: Summary of findings 204

5.4: General Discussion 207

Chapter 6: Study 7: Relationship between personality traits and cultural orientation in learned predictiveness- An online replication **212**

6.1: Introduction 213

6.2: Methods 217

6.2.i: Participants 217

6.2.i: Questionnaires 217

6.2.ii: Procedure 218

6.3: Results 218

Part A: Data treatment 220

Part B1: Analysis of behavioural data 221

B2: Cultural differences in learned predictiveness 223

B3: Differences between lab-based and online experiments 228

B4: Summary of findings 228

Part C: Comparison with normative data 229

Part D: Effects of personality traits on learned predictiveness 232

D1: The Big 5 232

C1.i: Further analysis: Simple moderation analysis 234

D2: Schizotypy 239

C2.i: Further analysis: Simple moderation analysis 240

D3: Summary of findings 245

6.4: General Discussion 245

Chapter 7: Thesis General Discussion **253**

7.1: Overview 254

7.2: Summary of findings 255

7.2.i: Studies 1-4 (Blocking and Learned Predictiveness) 255

7.2.ii: Study 5 (Relationship between personality traits and cultural orientation in latent inhibition and learned predictiveness) 257

7.2.iii: Study 6: Relationship between personality traits and cultural orientation in latent inhibition - An online replication 258

7.2.iv: Relationship between personality traits and cultural orientation in learned predictiveness - An online replication 259

7.2.v: Summary 260

7.3: Elemental/analytical and configural/holistic processing 260

7.4: Role of language in attention allocation 264

7.5: Role of personality traits in learning 266

7.6: Plasticity and Psychopathology 268

7.7: Strengths and implications 269

7.7.i: Online experiments 269

7.7.ii: Clinical applications 270

7.8: Limitations and future directions 271

7.9: Conclusions 274

References **277**

Appendix A **308**

Appendix B **309**

Appendix C **310**

Appendix D 311

Appendix E 312

Appendix F 324

Appendix G 335

List of Figures

Chapter 3

Figure 3.1: Information screen for Study 1

Figure 3.2: Example of a) learned predictiveness trial, b) blocking trial in Stage 1

Figure 3.3: Feedback screen

Figure 3.4: Instructions for the test stage

Figure 3.5: Rating screen

Figure 3.6: Mean proportion correct across trials in Stage 1 and 2 in Study 1. Error bars represent standard error of mean.

Figure 3.7: Mean difference ratings to the stimuli during the test stage of Study 1. Error bars represent standard error of mean.

Figure 3.8: Mean proportion correct across trials in Stage 1 and 2 in Study 2. Error bars represent standard error of mean.

Figure 3.9: Mean difference ratings to the stimuli during the test stage of Study 2. Error bars represent standard error of mean.

Figure 3.10: Mean proportion correct across trials in Stage 1, 2 and 3 in Study 3. Error bars represent standard error of mean.

Figure 3.11: Mean difference ratings to the stimuli during the test stage of 1 and 2 in Study 3. Error bars represent standard error of mean.

Figure 3.12: Mean proportion correct across trials in Stage 1 and 2 in Study 4. Error bars represent standard error of mean.

Figure 3.13: Mean difference ratings to the stimuli during the test stage of Study 4. Error bars represent standard error of mean.

Figure 3.18: Adaptation of Study 1 design to the Honey network. a) Stage 1 of learned predictiveness; b) Stage 2 of blocking; c) Design table for Study 1

Chapter 4

Figure 4.1: Stage 1 instruction for latent inhibition task in Study 5

Figure 4.2: Test stage instructions for latent inhibition task in Study 5

Figure 4.3: Image A shows a filler trial presented for 1000 ms and Image B shows an ISI of 50 ms. Image C shows the preexposed stimulus (S). When the target letter "X" appears (Image D), participants press the spacebar as quickly as possible. This is then followed by an ISI of 50 ms. Image F shows the non-preexposed stimulus (H). If participants predict that "X" would follow subsequently after the letter "H" (Image H), they can also press the spacebar (Image G).

Figure 4.4: Stage 1 instructions for learned predictiveness task in Study 5

Figure 4.5: a) example of trial in Stage 1; b) example of feedback given in food allergist task

Figure 4.6: Stage 2 instructions for learned predictiveness task in Study 5

Figure 4.7: Test stage instructions for learned predictiveness task in Study 5

Figure 4.8: Example of test stage trials in food allergist task

Figure 4.9: Mean Reaction time to the preexposed (PE) and non-preexposed (NPE) across 10 2-trial blocks in Study 5. Error bars represent standard error of mean.

Figure 4.10: Mean Reaction time to the preexposed (PE) and non-preexposed (NPE) cues across 10 2-trial blocks separated by culture. Error bars represent standard error of mean.

Figure 4.11: Mean proportion correct across trials in Stage 1 and 2 in Study 5. Error bars represent standard error of mean.

Figure 4.12: Mean difference ratings to the stimuli during the test stage of Study 5. Error bars represent standard error of mean.

Figure 4.13: Mean proportion correct across trials in Stage 1 and 2 separated by culture in Study 5. Error bars represent standard error of mean.

Figure 4.14: Mean difference ratings to the stimuli during the test stage of Study 5 separated by culture for, a) AC/BD/VX/WY and b) EH/FG/IJ/KL. Error bars represent standard error of mean.

Figure 4.15: Illustration of the relationship between impulsive nonconformity predicting latent inhibition score that is moderated by culture (individualistic and collectivistic) demonstrated in Study 5.

Figure 4.16: Simple slope plot illustrating the relationship between impulsive nonconformity and latent inhibition score in Study 5. Different coloured lines represent different levels of moderator. Grey line (low - -1SD) refers to the individualistic group, and the orange line (high - +1SD) refers to the collectivistic group

Figure 4.17: Illustration of the relationship between conscientiousness predicting relevant stimuli ratings that is moderated by culture (individualistic and collectivistic) demonstrated in Study 5.

Figure 4.18: Simple slope plot illustrating the relationship between conscientiousness and ratings from relevant stimuli in Study 5. Different coloured lines represent different levels of moderator. Grey line (low - -1SD) refers to the individualistic group, and the orange line (high - +1SD) refers to the collectivistic group.

Chapter 5

Figure 5.1: Mean reaction time to the PE and NPE across 10 2-trial blocks in Study 6. Error bars represent standard error of mean.

Figure 5.2: Mean reaction time to the PE and NPE across 10 2-trial blocks separated by culture in Study 6. Error bars represent standard error of mean

Chapter 6

Figure 6.1: Mean proportion correct across trials in Stage 1 and 2 in Study 7. Error bars represent standard error of mean.

Figure 6.2: Mean difference ratings to the stimuli during the test stage of Study 7. Error bars represent standard error of mean.

Figure 6.3: Mean proportion correct across trials in Stage 1 and 2 separated by culture in Study 7. Error bars represent standard error of mean.

Figure 6.4: Mean difference ratings to the stimuli during the test stage of Study 7 separated by culture for, a) AC/BD/VX/WY and b) EH/FG/IJ/KL. Error bars represent standard error of mean.

Figure 6.5: Illustration of the relationship between extraversion predicting irrelevant stimuli ratings that is moderated by culture (individualistic and collectivistic) demonstrated in Study 7.

Figure 6.6: Simple slope plot illustrating the relationship between extraversion and ratings from irrelevant stimuli in Study 7. Different coloured lines represent different levels of moderator. Grey line (low - -1SD) refers to the individualistic group, and the orange line (high - +1SD) refers to the collectivistic group.

Figure 6.7: Illustration of the relationship between introvertive anhedonia predicting irrelevant stimuli ratings that is moderated by culture (individualistic and collectivistic) demonstrated in Study 7.

Figure 6.8: Simple slope plot illustrating the relationship between introvertive anhedonia and irrelevant stimuli in Study 7. Different coloured lines represent different levels of moderator. Grey line (low - -1SD) refers to the individualistic group, and the orange line (high - +1SD) refers to the collectivistic group.

List of Tables

Chapter 1

Table 1.1: Blocking design table (Kamin, 1969)

Table 1.2: Learned predictiveness design table (Le Pelley and McLaren, 2003)

Chapter 3

Table 3.1: Study 1 experimental design. Letters A to Z represent the different food items (stimuli)

Table 3.2: Study 3 design table. Letters E to S represent the different food items (stimuli)

Table 3.3: Study 4 design table. Letters A to Z represent the different food items (stimuli)

Chapter 4

Table 4.1: Design table as in Le Pelley and McLaren (2003). The letters A, B, C, D, E, F, G, H, I, J, K, L, V, W, X, Y represented the foods while Outcomes 1 to 4 represent the allergies.

Table 4.2: Bayesian Pearson's correlation matrix for stimuli shown in Stage 2 of the learned predictiveness task and the cues from the latent inhibition task in Study 5. AX/BY/CV/DW trials from the learned predictiveness task consist of stimuli previously shown in Stage 1 while EF/GH/IJ/KL trials consist of stimuli that is not previously shown in Stage 1. Therefore, AX/BY/CV/DW trials are comparable to the preexposed cues from the latent inhibition task and the EF/GH/IJ/KL trials are comparable to the non-preexposed cues from the latent inhibition task. Note: BF10 > 10*, BF10 > 30**, BF10 > 100***

Table 4.3: Summary of correlations from all participants and split by culture of the relationship between OLIFE subscales and latent inhibition in Study 5. *Note*: $p < 0.05$*. The LIScore was

calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Table 4.4: Summary of OLIFE subscales as coefficients and pre-exposed cues, nonpre-exposed cues and latent inhibition score as dependent variables from all participants and split by culture in Study 5. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Table 4.5: Summary of correlations from all participants and split by culture of the relationship between anxiety and latent inhibition in Study 5. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Table 4.6: Summary of correlations from all participants and split by culture of the relationship between the Big 5 personality traits and latent inhibition in Study 5. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Table 4.7: Summary of correlations from all participants and split by culture of the relationship between the OLIFE subscales and learned predictiveness in Study 5. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings.

Table 4.8: Summary of the OLIFE subscales as coefficients and relevant stimuli, irrelevant stimuli and learned predictiveness score as dependent variables in Study 5. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Table 4.9: Summary of correlations from all participants and split by culture of the relationship between anxiety and learned predictiveness in Study 5. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings.

Table 4.10: Summary of correlations from all participants and split by culture of the relationship between the Big 5 personality traits and learned predictiveness in Study 5. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings. R values italicised with an apostrophe represent p values that approach significance.

Table 4.11: Summary of the Big 5 personality traits as coefficients and relevant stimuli, irrelevant stimuli and learned predictiveness score as dependent variables in Study 5. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Chapter 5

Table 5.1: Means and standard error of mean of pre-exposed cues, nonpre-exposed cues and latent inhibition score, n (total) = 394 in Study 6.

Table 5.2: Summary of correlations from all participants and split by culture of the relationship between the OLIFE subscales and latent inhibition in Study 6. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Table 5.3: Summary of correlations from all participants and split by culture of the relationship between anxiety and latent inhibition. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Table 5.4: Summary of correlations from all participants and split by culture of the relationship between the Big 5 personality traits and latent inhibition in Study 6. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Table 5.5: Summary of the Big 5 personality traits as coefficients and pre-exposed cues, nonpre-exposed cues and latent inhibition score as dependent variables in Study 6. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Chapter 6

Table 6.1: Means and standard error of mean of relevant stimuli, irrelevant stimuli and learned predictiveness score for both lab-based and online experiments.

Table 6.2: Descriptive statistics for OLIFE, Big 5, trait anxiety and personal cultural orientation subscales in Study 5, 6, 7 and normative data.

Table 6.3: Correlation matrix for OLIFE subscales. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Table 6.4: Correlation matrix for Big 5 subscales. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Table 6.5: Summary of correlations from all participants and split by culture of the relationship between the Big 5 personality traits and learned predictiveness in Study 7. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings.

Table 6.6: Summary of the Big 5 personality traits as coefficients and relevant stimuli, irrelevant stimuli and learned predictiveness score as dependent variables in Study 7. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Table 6.7: Summary of correlations from all participants and split by culture of the relationship between the OLIFE subscales and learned predictiveness in Study 7. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings.

Table 6.8: Summary of the OLIFE subscales as coefficients and relevant stimuli, irrelevant stimuli and learned predictiveness score as dependent variables in Study 7. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Table 6.9: Summary of how variations in particles, strokes and verbs can change the contextual meaning or pronunciation of words in Chinese, Japanese and Korean.

Chapter 7

Table 7.1: Summary of individual and cultural differences in results across Study 5, 6 and 7.

Chapter 1:

Introduction: Learning and Attention

1.1: Overview

This chapter will begin by defining some common terminology used in the field of associative learning. It will then describe the effects of overshadowing, blocking and conditioned inhibition and explain how these effects can be accounted for by the Rescorla-Wagner model (Rescorla and Wagner, 1972). The limitations of this model will also be discussed. Next, attention-based learning models such as the Mackintosh Theory (Mackintosh, 1975) and the Pearce-Hall model (Pearce and Hall, 1980) will be described, and their strengths and weaknesses will be discussed. This chapter will end with a discussion on hybrid models introduced to overcome the limitations faced by traditional learning models.

1.2: Introduction

Associative learning refers to a change in behaviour by an organism as a result of changes in the world (De Houwer, 2009). One of the earliest observations of associative learning was described by Pavlov (1927). When it was time to feed his dogs, Pavlov would ring a bell to signal that it was mealtime and he noticed that the dogs would naturally salivate when the food was given. After that, he observed that whenever he rings the bell, the dogs would also salivate without food being present. To put into associative learning terms, the food was an unconditioned stimulus (US - biologically significant stimulus) and their natural salivation towards the food was an unconditioned response (UR - a biological response towards the US). As Pavlov always rings the bell before providing food, the dogs would have associated the ringing of the bell with food, making the bell sounds the conditioned stimulus (CS - previously neutral stimulus that acquired a response from repeated pairings with the US) and consequently, produce a conditioned response (CR - response to the CS) i.e., salivation whenever they hear it ring.

Besides salivation behaviour, eyeblink response is also commonly used in associative learning studies. Many eyeblink conditioning studies have been conducted in rabbits and the task would generally involve puffing air from a nozzle near the eye (US) and the rabbits would blink (UR). A tone would also be presented almost simultaneously as this happens (CS). If the rabbits blink when they hear the tone but before the air is being puffed, the eyeblink would be scored as a CR (Woodruff-Pak, 1988). Eyeblink conditioning studies have also been conducted in humans to study the neurobiology of learning and memory (see Cheng et al., 2020 for review).

One particularly common method for exploring associative learning in humans is with the use of causal learning tasks. In a typical causal learning task, participants are first presented with a series of trials where certain stimuli are paired with certain outcomes, and these participants will then be asked to rate the likelihood of the stimuli predicting the outcomes (Luque and Vadillo, 2011). Under certain conditions, human causal learning is comparable to the underlying processes of associative learning in animal conditioning (Dickinson, Shanks and Evenden, 1984; Shanks and Dickinson, 1988; see Chapman and Robbins for review).

1.3: Overshadowing and Blocking

An emphasis within the study of associative learning has been to understand cue competition effects, which occurs when two stimuli are compounded with each other and paired with the same outcome (Wheeler and Miller, 2007). Cue competition effects are of interest for at least two reasons. First, they frequently demonstrate the failure of learning an association between a cue and an outcome, despite the repeated pairings of that cue with the outcome – at face value, this is a counter-intuitive result. Second, impairments in cue competition phenomena have been associated with clinical conditions (e.g., schizophrenia) that place significant mental health burdens on individuals and also economic strain upon health services. By gaining a better understanding of the mechanisms of cue competition, we can also therefore gain a better understand of the cognitive disruptions that underpin these clinical conditions and ultimately recommend interventions.

Examples of cue competition effects include overshadowing and blocking, In the case of overshadowing, if one of the CSs (A) within a compound (AX) is more salient than the other (X) when paired with an outcome (e.g., food), the conditioning of the weaker CS (X) will be weaker, it is said to be "overshadowed" (Pavlov, 1927). If A was previously trained to predict food, it will further "block" the amount of conditioning X will have for food. Therefore, the difference between overshadowing and blocking effects is that overshadowing occurs in one training stage of conditioning while blocking, typically, requires two stages of training. Overshadowing has been demonstrated in rats (Mackintosh, 1976), pigeons (Leising, Garlick and Blaisdell, 2011) and humans (Endo and Takeda, 2004; Prados, 2011; Schmidt and De Houwer, 2019; see McLaren et al., 2014 for review).

In the classic demonstration of blocking, Kamin (1969) conducted a study comprising three stages and with two groups of rats, see Table 1.1 for summary of design. In Stage 1, Group 1 received trials where a noise (CS) was paired with a foot shock (US). In Stage 2, both groups received trials of a compound CS (light + noise) paired with a foot shock. In the test stage, only light was presented by itself. His results show that Group 2 showed good conditioning, while Group 1 showed no evidence of conditioning towards light. Prior conditioning with noise was then proposed to have "blocked" the learning of associations between light and shock.

Table 1.1: Blocking design (Kamin, 1969)

Group	Phase 1	Phase 2	Test
1	16 (Noise → Shock)	8 (Light + Noise → Shock)	Light?
2	-	8 (Light + Noise → Shock)	Light?

These findings hold significant implications because it demonstrates that conditioning does not simply happen because a CS is paired with a US. In Phase 2, the light and the shock are repeatedly paired but only in Group 2 does the light go on to elicit a CR. In Group 1, no reliable CR to the light was observed. Kamin (1969) suggested that learning only occurs when the CS presents new information about the US, and relatively little learning occurs when there is no new information. In relation to the results found, rats in Group 1 already learned that noise predicts shock and therefore, light is redundant in predicting the unsurprising US. Since its discovery, blocking has been shown in rabbits (Betts, Brandon and Wagner, 1996), pigeons (Leyland and Mackintosh, 1978), and molluscs (Sahley, Rudy and Gelperin, 1981) and has been replicated in a variety of experimental procedures such as taste-aversion (Gallo and Cándido, 1995) and fear conditioning (Li and McNally, 2014). Blocking has also been demonstrated in humans (Haselgrove and Evans, 2010; Le Pelley, Beesley, Griffiths, 2014; Le Pelley, Oakeshott and McLaren, 2005; Moran, Al-Uzri, Watson, Reveley, 2003).

The food allergist task in the context of blocking is of interest as it will be adapted with a learned predictiveness procedure as later shown in Study 1 of this thesis. Le Pelley et al. (2005) asked their participants to pretend to be an allergist and were tasked to find out which meals cause a fictitious patient to have an allergic reaction. Their results showed that participants rated a food item (B) as likely to cause an allergic reaction if it was previously compounded with another food item (A) that also caused an allergic reaction (AB+). However, if A was previously presented by itself and caused an allergic reaction (A+), participants showed little learning about B. This finding is consistent with Haselgrove and Evans (2010), who also used a similar task and found that participants provided higher ratings for the food item that had not previously been compounded with a food item with a history of causing an allergic reaction [1].

Footnote 1: This effect was attenuated in participants high in schizotypy, see Chapter 2.5.ii for more details.

1.4: The Rescorla-Wagner (1972) Model

$$\Delta VA = \alpha\beta(\lambda - VT) \qquad \text{Equation 1:}$$

In order to account for cue competition phenomena such as overshadowing and blocking Rescorla and Wagner proposed a mathematical model of learning. According to Rescorla and Wagner (1972), conditioning provides an opportunity for organisms to change the strength of associative connections between CSs (cues) and the US (outcome). The change in the strength of the association between a CS (in this case A) and the US is governed by Equation 1, in which ΔVA is the change in the strength of the CSA - US association. Associative strength (VA) refers to the strength of the connection between internal representations of the CS and US, which determines the strength of the CR. When there is more than one individual CS (e.g., AX) presented as a compound to predict a US, the associative strengths of all the CSs that are present in the trial are then totalled ($VT = VA + VX$). The change in associative strength in CSA is determined by the discrepancy between λ (magnitude of the US) and the VT. The λ represents the maximum strength the CSA - US association can achieve. The extent of this change in associative strength is moderated by two learning parameters, α (salience of the CS) and β (salience of the US), with values between 0 and 1.

The discrepancy ($\lambda - VT$) is significant because it shows the extent to which the US is surprising (Pearce, 2008). When V is smaller than λ (consequently producing a large value), the CSA will be a poor predictor of the US and it will be surprising and show rapid conditioning. When V is a value close to λ (small value), the CSA will be a good predictor of the US and it will not be surprising and show weaker conditioning. This formula can thus be used to articulate how animals learn about surprising USs more readily. When CSs are presented in a compound, the

Rescorla-Wagner model predicts that they will compete with each other for conditioning. For example, when AX is paired with shock (US), CSA and CSX will gain less associative strength each than if they were separately paired with the same US. This phenomenon is overshadowing (Pavlov, 1927).

The effects of blocking can be explained by the Rescorla-Wagner (1972) model. When noise (CS) was paired with shock (US) in Stage 1, there was no prior expectation of shock, therefore an association between the noise and shock will develop. As training continues, noise will eventually predict the shock causing the decrease in the surprisingness of the shock. Ultimately, learning of this association will reach asymptote and no further learning happens. In Stage 2, when the light is introduced for conditioning, the increment in its associative strength will be determined by the difference between λ and VT (i.e., surprisingness of US). The pre-training of noise means that the surprisingness of the US is close to zero and therefore all stimuli, including the light will gain little associative strength. Since Group 2 received no training in phase 1, both the noise and the light will gain associative strength causing light to elicit a stronger CR than in Group 1.

To further support his results, Kamin first repeated the noise → shock training followed by the light + noise → shock training. During the test phase, when the light was presented, the rats showed little conditioned responding, replicating his prior findings. In a second group of rats, when he paired the light and noise, the intensity of the shock was increased from 1 milliampere to 4 milliampere, and during the test stage, the rats showed more fear towards the light. He proposed that the light predicted new information (i.e., stronger shock) and thus, produced an unblocking effect. To validate these results, he also presented a third group of rats in which the stronger magnitude of shock was presented in both Stage 1 (noise → shock) and 2 (light + noise → shock).

The results revealed similar blocking effects as the rats from Group 1. The Rescorla-Wagner model can also explain the effects of unblocking. The increased intensity of the shock would increase the existing λ and thus allow for further conditioning to occur by the new CS (light) as the difference between λ and VT is > 0.

1.5: Conditioned Inhibition

Moreover, the Rescorla-Wagner model can also account for the effects of non-reinforcement such as those in conditioned inhibition. When, for example, a tone is consistently paired with shock, its associative strength will approach asymptote. If the tone is then subsequently compounded with a light and this compound signals non-reinforcement, the absence of any outcome will mean that λ is zero. Since the light is a novel stimulus, V_{light} will be zero. Prior conditioning of the tone will mean that V_{tone} is positive and following Equation 1, the compound trial will reduce the associative strength of light and because it is already starting at zero, V_{light} will acquire negative value. According to Wagner and Rescorla (1972), any stimulus that acquires negative strength will be a conditioned inhibitor, and hence, subsequent testing will show responding to only the tone by itself and none to the tone + light compound. Furthermore, attempts at conditioning the inhibitor should be slow (the so-called retardation test of conditioned inhibition), and also the inhibitory should offset conditioned responding to other excitatory CSs (the so-called summation test). Conditioned inhibition can be found in rats (Baker, 1974), pigeons (Rescorla, 1982) and humans (Laing et al., 2021; Melchers, Wolff and Lachnit, 2006).

Blocking, overshadowing and conditioned inhibition were early demonstrations of cue interaction effects, and provided important demonstrations that learning about one particular cue is modulated by the presence of other cues. While the Rescorla-Wagner model successfully predicts these effects, a limitation of the model is that it does not formally account for how *learned* changes in the saliency of CS can influence the associative strength of a CS to a US. This is because the learning rate parameter for the CS within equation 1 is set by the physical properties of the stimulus and is fixed. However, an example of how exposure to stimulus might change its associability can be found in latent inhibition.

1.6: Latent Inhibition

Latent inhibition refers to the retardation in subsequent conditioning when the CS is paired with a US following the presentation of that CS by itself. It was first discovered by Lubow and Moore who pre-exposed goats and sheep to a visual stimulus (CS) 10 times with no reinforcement (US). In the test phase, the visual stimulus was then paired with shock (US). They found that the animals would take longer to reach the learning criterion compared to the animals who were not pre-exposed to the visual stimulus. Latent inhibition is a reliable phenomenon that has been demonstrated in a variety of species, for example, in goats and sheep (Lubow and Moore, 1959), rats (Kaye and Pearce, 1987). It can also be found in humans (Evans, Gray and Snowden. 2007; Granger, Moran, Buckley and Haselgrove, 2016, see Byrom, Msetfi and Murphy, 2018 for review).

Studies testing latent inhibition in humans usually involve two stages: a pre-exposure and a test phase. A typical pre-exposure phase would also be accompanied with a masking task with the purpose of engaging participants' attention in controlled information processing and consequently, allow the pre-exposed stimulus to automatic processing (Lubow and Gewirtz, 1995). An example of a masking task could be counting the number of one nonsense syllables presented among a list of nonsense syllables (Baruch, Hemsley and Gray, 1988a). After the masking task, participants would proceed to the test phase where the pre-exposed stimulus is presented, and participants are asked to learn the relationship between the pre-exposed stimulus and an outcome. Meanwhile, another group of participants who did not experience a pre-exposure phase would also be asked to learn the same relationship between the stimulus and outcome.

Evans et al. (2007) introduced a new latent inhibition procedure that removes the masking task. This new procedure is also less susceptible to learned irrelevance (disrupted learning due to the uncorrelated presentations of the US and CS in the preexposure stage of the experiment) as the US will not be presented during the preexposure stage. At the start of the experiment, participants were asked to press the spacebar whenever they saw the letter “X” appear on screen or when they could predict the appearance of “X”. During the preexposure stage, non-target letters and the pre-exposed stimulus were presented to the participants. There was no presentation of the target letter “X”. The test stage followed continuously without any delays. “X” appeared consistently after the pre-exposed and a nonpre-exposed letter, and randomly after the non-target letters. Evans et al. (2007) found an effect of latent inhibition, where response times to the non-pre-exposed letter were faster than to the pre-exposed letter.

Granger et al. (2016) introduced some modifications to the Evans et al. (2007) task to further minimise the effects of learned irrelevance that may still be present during the pre-exposure stage of the task. Now, during the pre-exposure stage, they asked participants to say each letter out loud, thus directly establishing all of the stimuli in Stage 1 as relevant as the participants. They also included an additional instruction before the test stage to inform the participants to stop saying the letters aloud but to press “X” whenever it appears or when they can predict the appearance of “X”. By making this change to the task, participants are no longer expecting the presentation of X during Stage 1, a confound which may have resulted in the pre-exposed cue (which in the Evans et al task was paired with the unexpected absence of X) becoming established as a conditioned inhibitor. Furthermore, as participants must actively say each letter on screen (including the pre-exposed cue), it is difficult to make the argument that the pre-exposed cue has acquired a degree of learned irrelevance. This new procedural method has successfully reproduced the effects of latent inhibition as they found that reaction times to the non-preexposed stimulus were shorter than to the preexposed stimulus, indicating a retardation of learning to the preexposed stimulus. Latent inhibition is an example of how learning can influence the associability of the CS and thus, is in conflict with the predictions of the Rescorla-Wagner model. Alternative models and theories have therefore been introduced to take into consideration the changes in associability of a stimulus (Mackintosh, 1975; Pearce and Hall, 1980; Wagner, 1981).

1.7: The Mackintosh (1975a) Theory

According to Mackintosh (1975a) the amount of processing that a CS receives is adjusted by experiences. More specifically, the attention that a stimulus captures is determined by how accurately it predicts the outcome. Mackintosh proposed that the attention of a CS will increase if it is the best available predictor of an outcome, and if it is a poor predictor of an outcome, the attention will fall. Mackintosh formalised this idea in a mathematical theory of learning, the equation for which can be seen in Equation 2.

$$\Delta V_A = \theta(\lambda - V_A) \qquad \text{Equation 2:}$$

ΔV_A refers to the change in associative strength of CS_A on a given trial. θ is a learning rate parameter and λ is the asymptote of conditioning supported by the US. θ is divided into α, determined by the attention of CS and β, determined by properties of the US. Unlike the Rescorla-

Wagner model, Mackintosh proposes that α changes as a result of learning about the CS, and the changes were:

a. $\Delta\alpha_A$ is positive if $|\lambda - V_A| < |\lambda - V_X|$

b. $\Delta\alpha_A$ is negative if $|\lambda - V_A| \geq |\lambda - V_X|$

V_X is the total associative strength of all other stimuli apart from A. If $|\lambda - V_A|$ is smaller than $|\lambda - V_X|$ (i.e., prediction error of A is smaller than prediction error of all stimuli except A), then A is the better predictor of the outcome of the trial compared to all other stimuli. Therefore, $\Delta\alpha_A$ will be positive and the attention of A will increase. Conversely, if $|\lambda - V_A|$ is larger than or equal to $|\lambda - V_X|$, then A is the worst predictor of the outcome of the trial compared to all other stimuli. Therefore, $\Delta\alpha_A$ will be negative and the attention of A will decrease, and relatively little learning will occur. In essence, Equation 2a and 2b compares the prediction errors of the target stimulus, A, with the prediction errors of all other stimuli on that trial and if A is the best predictor, then more attention will be paid to it, and if it is not, animals will learn to ignore it.

1.8: Intradimensional (ID)/Extradimensional (ED) Shift Effect

One measure that has been used to examine the influence of attention on learning is the *associability* of a cue. The idea here is that, as a consequence of learning, the extent to which a stimulus comes to capture attention will change, and hence will modify the extent to which it can be associated with other events. An example procedure to demonstrate this is an intradimensional (ID) and extradimensional (ED) shift study (George and Pearce, 1999; Mackintosh and Little, 1969). Mackintosh and Little (1969) presented pigeons with coloured lines (red, yellow, blue, green) of different orientations (0°, 90°, 45°, 135°) and trained them to discriminate between colour and orientation. In Stage 1, 4 pigeons were trained with red+, yellow- and 4 pigeons with yellow+, red- (colour relevant) as well as 4 pigeons with 0°+, 90°- and 4 pigeons with 90°+, 0°- (orientation relevant). In Stage 2, new coloured lines (blue and green) of new orientations (45°, 135°) were presented to the pigeons. Pigeons in the ID group were required to solve a discrimination between stimuli that belonged to a relevant dimension in Stage 1. Pigeons in the ED group were required to solve a discrimination between stimuli that belonged to the irrelevant dimension in Stage 1.

Their results showed that pigeons in the ID shift group learned the task quicker than the ED shift group, suggesting that associability of cues was enhanced by initial training in Stage 1, which led to positive transfer effects to Stage 2. In other words, pigeons who were trained to respond to colour (red and yellow) in Stage 1, will have paid more attention to the colour dimension in Stage 2, and will show faster learning about the blue and green lines than the 45° and 135° lines. These results are consistent with the Mackintosh theory where previously relevant predictors will show greater learning.

George and Pearce (1999) also conducted an intradimensional (IDS) extradimensional (EDS) shift task on two groups of pigeons. They presented both groups with compounds of stimuli comprising squares that could be composed of one of two different colours (blue and yellow) and squares comprising one of two different slanting line orientations (backwards and forwards). In the first group, a reward was given if the pigeons pecked only on the yellow squares (relevant) regardless of line orientation (irrelevant) (IDS), and in the second group, a reward was given if the pigeons pecked only on the forward slanting line (relevant) regardless of colour (irrelevant) (EDS). After the pigeons successfully learned the discriminations, new squares of different colours (red and green) and line orientations (horizontal and vertical) were presented. Now, only colour but not line orientation was rewarded. The results found that the IDS group showed more rapid learning of the new discrimination rules compared to the EDS group because for the IDS group, pecking the red square would signal food and pecking the green square would signal no food regardless of orientation of lines, which is consistent with the colour relevant rules learned in Stage 1. For the EDS group, the pigeons learned that the orientation of lines were relevant to signalling food in Stage 1 and therefore, would pay more attention to this information initially in Stage 2, consequently finding the new discrimination rule to be harder to learn. This is consistent with the Mackintosh theory where previously relevant predictors will show greater learning.

1.9: Learned Predictiveness

Attentional shifts or biases towards subsequent learning can also be found in humans (Haselgrove et al., 2016; Le Pelley and McLaren, 2003; Le Pelley, Schidmt-Hansen, Harris, Lunter and Morris, 2010). Learned predictiveness refers to the relatively rapid learning about cues that have previously been established as reliable predictors of an outcome relative to cues that have been established as unreliable predictors of an outcome (Le Pelley and McLaren, 2003).

Le Pelley and McLaren (2003) embedded a learned predictiveness design within a food allergist task that involved presenting participants with a fictitious patient “Mr X”, who, after consuming pairs of foods (e.g., foods A and V, which may be broccoli and carrot, for example), see Table 1.2 for design table) suffers from allergic responses (outcomes) as a consequence. Participants were tasked with determining which foods caused which allergies.

Table 1.2: Learned predictiveness design table (Le Pelley and McLaren, 2003).

Stage 1	Stage 2	Test
AV - O1	AX - O3	AC
BV - O2	BY - O4	BD
AW - O1	CV - O3	VX
BW - O2	DW - O4	WY
CX - O1	EF - O3	EH
DX - O2	GH - O4	FG
CY - O1	IJ - O3	IJ
DY - O2	KL - O4	KL

During Stage 1, cues A and C reliably predicted Outcome 1 while cues B and D reliably predicted Outcome 2. Cues V to Y were paired with both Outcome 1 and 2 equally often and therefore provided no basis for discrimination. This successfully established cues A to D as relevant predictors and cues V to Y as irrelevant predictors.

In Stage 2, participants were provided with a new-learning context where the previously "good predictors" (A to D) are paired with the previously established "bad predictors" (V to Y) in never-before-seen food compounds which were paired with new outcomes (Outcomes 3 and 4). Novel compounds were used in Stage 2 to eliminate biases that may result from the direct transfer of learning from Stage 1. Consider the trial, "AX-O3". In this learning context, A predicts Outcome 3 as much as X, thus these cues were equally good predictors of the trial outcome. The crucial point here was whether prior knowledge of relevance learnt in Stage 1 biased the learning rate of the current cues to the new outcome.

The Mackintosh (1975a) theory will predict that more attention will be paid towards a cue that has a history of being a good predictor (Food A, B, C and D) and less attention would be paid towards one that was a bad predictor (Food W, V, X and Y). Therefore, if participants showed a learning bias to the previously relevant A and ignored the previously irrelevant X, it was expected that learning the A - Outcome 3 association would have been easier than learning the X - Outcome 3 Association. More generally, an influence of attention from Stage 1 on learning during Stage 2 would be reflected by stronger cue-outcome associations for cues A to D as compared to V to Y. This was exactly what was observed by Le Pelley and McLaren during the test stage where participants were asked to rate the associations of compounds AC & VX with Outcome 3 and BD & WY with Outcome 4.

Learning about the predictiveness of cues can also influence stimulus processing as demonstrated by studies assessing attention based on eye movement (Beesley, Nguyen, Pearson, Le Pelley, 2015; Le Pelley, Beesley and Griffiths, 2011) and spatial cueing (Haselgrove et al., 2016; Le Pelley, Vadillo and Luque, 2013). Le Pelley et al. (2011) presented participants with a learned predictiveness task (Le Pelley and McLaren (2003) and tracked their eye movements whilst they performed the task. Their results showed that participants spent longer time gazing at the relevant cues on each trial than the irrelevant cues in Stage 1. This bias in overt attention persisted in Stage 2, where all the cues were equally predictive of the outcomes. This finding thus provides evidence that prior knowledge of relevance can have an influence on overt attention.

Mitchell, Griffiths, Seetoo and Lovibond (2012) asked participants to predict the shape a tree (outcomes) will form from a set of cross-pollination seeds (cues). They also introduced some modifications to the Le Pelley and McLaren (2003) design. Mitchell et al. (2012) divided Stage 1 training of cues to 5 blocks to facilitate learning. In Stage 2, participants were split into two groups, where one group was only given 1.25 seconds (short group) of looking at the cues before making a prediction of the outcome while the other group was given 5 seconds (long group). Their results demonstrated a learned predictiveness effect and there was a bias of overt attention on previously predictive cues. Participants from the short group had stronger eye gaze bias towards the predictive cues compared to participants from the long group suggesting that stimulus selectivity was further intensified when attentional resources are scarce.

Haselgrove et al. (2016) also conducted a learned predictiveness task tracking eye movement of participants during Stage 1 and replicated the finding of longer gaze time on relevant cues than irrelevant cues [2]. To further investigate whether conditioning in Stage 1 resulted in a bias in overt attention in Stage 2, Haselgrove et al. used a new cover story for Stage 1 and replaced the Stage 2 task with a dot-probe task. In the dot-probe task, they asked participants to fixate on a cross at the centre of the screen after which two words would appear briefly on either side of the fixation cross. The words would be a previously relevant cue and a previously irrelevant cue from Stage 1. A triangle would subsequently appear on either side of the fixation cross, where the relevant and irrelevant cue words previously appeared, and participants would have to press the spacebar as soon as they saw the triangle. If the triangle appeared at the location where the relevant cue word previously appeared, it would be a congruent trial and if the triangle appeared at the location where the irrelevant cue word previously appeared, it would be an incongruent trial. Their results found a faster response for congruent trials than incongruent trials, corroborating previous evidence of an attentional bias towards relevant cues.

Footnote 2: There was evidence of participants low in introvertive anhedonia demonstrating longer gaze time towards the relevant cue, see Chapter 2.5.ii.

The Mackintosh theory also provides an alternate account for blocking. The Rescorla-Wagner model states that blocking occurs because shock (US) was already predicted by the noise (CS) and thus when compounded with the light (CS), no further learning will occur. The Mackintosh theory, however, proposes that on the first compound trial, the attention paid towards the light will be relatively higher due to its novelty thus gaining associative strength. During this trial, animals will also discover that the light is a much worse predictor of shock than the noise and its associability will fall. Consequently, no further associative strength is gained. Mackintosh (1975b) conducted a series of blocking experiments measuring the conditioned suppression of licking in rats and found that blocking requires at least one trial to develop, suggesting that blocking is not due to cue competition to associate to reinforcement but rather once the rats have learned that the newly compounded stimulus is redundant, no further learning of this stimulus would occur, but see Dickinson, Nicholas and Mackintosh (1983).

The Mackintosh theory assumes that latent inhibition occurs as a result of a decline in the associability of a pre-exposed stimulus (represented by a change in α). For example, when a light (CS) is presented with no outcome (US), the Mackintosh theory predicts that attention to the light will decline. This is because light was not a relatively better predictor of nothing compared to the surrounding environment (context) which is frequently, and reliably, paired with nothing. Therefore, when the light is subsequently paired with a shock (US), the low value of α will cause the increment of associative strength on any trial to be relatively small. However, the Mackintosh theory does not specify whether the decline in associative strength is dependent on whether the context of the preexposure is same or different. Channell and Hall (1983) first preexposed a group of rats to light before proceeding with a light-food conditioning. They found that responding rates were lower for this group of preexposed rats compared to a group of rats that was not preexposed to light, consistent with a latent inhibition effect. However, this latent inhibition effect was reduced if the preexposed group of rats were first preexposed in a different environment (context) than when they were given compound conditioning. Therefore, the Mackintosh theory correctly emphasises the role of the context in latent inhibition but struggles to explain every facet of latent inhibition such as context-specificity of latent inhibition and how latent inhibition is facilitated by context pre-exposure (Holmes and Harris, 2010).

1.10: The Pearce-Hall (1980) Model

The concept of attention being directed towards good predictors of outcomes makes sense – it permits organisms to better exploit regularities in their environment by selectively attending to stimuli that are reliable predictors of important events, thus reducing the visual processing demands. However, there is also a sense in which the Mackintosh theory is rather counterintuitive, this is because it is also adaptive for organisms to attend to stimuli that are associated with uncertainty, in order to better learn about stimuli when the consequences are discrepant with knowledge. Once the outcome of a trial is known, it makes little sense for the organism to continue to devote processing power to the cue that preceded it. Evidence towards this conception comes from Hall and Pearce (1979) who conditioned one group of rats with a tone (CS) with a small shock (US), and another group with light (CS) and a small shock (US). In Stage 2, they paired the tone with a larger shock. Based on the Mackintosh theory, the former group of rats should show greater fear of the tone than the latter group of rats because it was previously a good predictor. However, their results showed the opposite result, that conditioning of tone → shock in Stage 1 retarded the learning of tone → SHOCK in Stage 2. This implied that there was a negative transfer of learning from Stage 1 to 2 and this effect is known as Hall-Pearce negative transfer. These results are in contrast with the Mackintosh theory as it suggests that rather than an increased attention, the attention to the CS decreased as a result of conditioning.

The effect of negative transfer has also been found in humans. Griffiths, Johnson and Mitchell (2011) embedded a negative transfer design within a food allergist task to provide further support to the uncertainty principle. There were two groups of participants, negative transfer and change. In Stage 1, participants in the negative transfer group were presented with six trials of A+ while participants in the change group were presented with five trials of A+ followed by one trial of A-. In Stage 2, both groups were presented with five trials of A++. Their results showed that initial learning in Stage 2 was slower for the negative transfer group than the change group consistent with the uncertainty principle. However, this result was not replicated, including by the authors themselves (Le Pelley et al., 2016).

To explain the effects of negative transfer, Pearce and Hall (1980) proposed a model where attention to a stimulus is seen as necessary to learn about its significance, but once learning has reached asymptote, no further attention should be paid towards it (Pearce and Bouton, 2011). Instead, attention should be paid towards stimuli that are surprising or unexpected. To formally express these ideas, the attention to a CS and consequently its associability will be governed by the following, see Equation 3.

$$\alpha_A^n = |\lambda - V_T|^{n-1} \qquad \text{Equation 3:}$$

α refers to attention as in the Mackintosh theory (salience of CS), but this is determined by how surprising the CS ($\lambda - \Sigma V$) is. α^n refers to the value of α on trial n, where it is determined by the absolute value of discrepancy, $|\lambda - \Sigma V|$, for the previous trial. For example, if trial_n = 2, then the saliency of CS_A depends on how surprising the CS was on trial 1.

Going back to Hall and Pearce (1979), when the rats successfully learned the tone → shock association, no more learning will occur because it is no longer surprising. Subsequently, in Stage 2, when presented with tone → SHOCK, learning will be slower compared to the group who was previously conditioned with light → shock because the tone was a familiar predictor, and thus not surprising, but light was novel and therefore, surprising.

Kaye and Pearce (1987) repeatedly exposed a light (CS) to a group of rats. In their study, there were two groups of rats: familiar group and novel group. Stage 1 consisted of 12 sessions where, for the familiar group, the rats were given trials with a light for 10 seconds, while the novel group were presented with nothing. At the end of Stage 1, both groups were given a single pre-test session where a light was occasionally presented for 10 seconds. In Stage 2, both groups were conditioned with the light (CS) serving as a signal for food (US). Their results showed that in Stage 1, the orienting response to light weakened across sessions (*habituation*). In the pre-test session, the orienting response to the light was higher in the novel group than in the familiar group. In Stage 2, the novel group showed a more rapid conditioning of light to food while there was a slower progress in the familiar group, suggesting a latent inhibition effect. The Pearce-Hall model predicts that attention will decline to a stimulus that is repeatedly presented by itself because it is a predictor of *nothing*. Thus, when paired with a US, its associative strength will be retarded compared to a novel stimulus.

Further support for the Pearce-Hall model comes from partial reinforcement studies. Partial reinforcement schedule occurs when a CS is occasionally followed by a US and a continuous reinforcement schedule occurs when a CS is continuously followed by a US (Pearce, 2008). This model predicts that during a continuous reinforcement schedule, attention to the CS would eventually be very low while during a partial reinforcement schedule, attention to the CS would be maintained at a high level, and this has been demonstrated by several studies (Haselgrove, Esber, Pearce and Jones, 2010; Pearce, Redhead and Aydin, 1997; Swan and Pearce, 1988; Weinstock, 1954). Weinstock (1954) trained two groups of rats to run down an alley to gain food. One group was continuously rewarded with food (Group Continuous) while the other only received food on half of the trials randomly (Group Partial). His results showed that the running speed of rats from both groups increased with more trials but Group Continuous eventually ran faster than Group Partial. During the extinction phase, where food is no longer given to both groups, extinction occurred rapidly for Group Continuous as the rats quickly gave up running down the alley and took a long time to reach the goal on each trial. However, Group Partial persisted running down the alley rapidly relatively more times than Group Continuous. Therefore, these results are consistent with the predictions made by the Pearce-Hall model.

Haselgrove, Esber, Pearce and Jones (2010) first conditioned four auditory stimuli to rats (A, B, X, Y) where A and B were consistently paired with food while X and Y were paired with food 50% of the trials. All four stimuli were presented the same number of times. After this training, the rats were divided into two groups (AY-BY - continuous group) and (AY-AX - partial group), where they were presented with compounds composed of a previously continuously reinforced stimulus and a previously partially reinforced stimulus in a discrimination task. Specifically, the continuous group was presented with AY+ and BY-, and the partial group was presented with AY+ and AX-. This ensures that rats in the continuous group continue to attend to the previously continuously reinforced stimulus while the rats in the partial group continue to attend to the previously partially reinforced stimulus within the compound. The Pearce-Hall model predicts that more attention would be paid to the stimulus that was partially reinforced instead of continuously reinforced with food and this is consistent with the Haselgrove et al.'s (2010) results where the partial group solved the discrimination task more readily than the continuous group.

1.11: Hybrid Models

Based on the literature presented above, it can be said that attention paid to a cue can change as a consequence of its predictiveness. The change in attention is proposed to be governed by two principles: i) predictiveness principle, where stimulus with a history of being a good predictor of an outcome will be attended to more and ii) uncertainty principle, where more learning will occur to a stimulus that is followed by a surprising outcome (see Le Pelley, Mitchell, Beesley, George and Will, 2016 for review).

Le Pelley (2004) introduced a hybrid model with three components: a summed error term (learning about stimulus as a result of its prediction error) as in Rescorla and Wagner (1972), an α component, which refers to the Mackintosh (1975a) formulation to determine *attentional associability*, and a σ component, which refers to the Pearce-Hall (1980) formulation to determine *salience associability*. The product of these three components determines the total associability of any given stimulus during conditioning and learning. According to this model, there are two types of attention, a Mackintosh-type attentional mechanism, which essentially addresses the problem of stimulus selection, and a Pearce-Hall-type attentional mechanism, which specifies the amount that is learned about the selected stimuli. In other words, the former attentional mechanism informs animals on which stimulus to attend to and the latter determines how much is learned about the stimulus.

Pearce and Mackintosh (2010) also proposed a hybrid model which incorporates both Mackintosh (1975a) and Pearce-Hall (1980) theories. They argued that the use of the Rescorla-Wagner error term twice (once in the summed error term and once in the Pearce-Hall rule) is unnecessary and proposed a simpler model by modifying the Pearce-Hall equation. In this modification the changes in the stimulus were determined by how well only it can predict its own consequences, and not by how well its consequences are predicted by all stimuli present on that trial. Therefore, this model can also account for why conditioning in a new context with a CS that has previously been reinforced is retarded compared to a CS that is novel, such as the effects found in negative transfer (Hall and Pearce, 1979) and partial reinforcement (Kaye and Pearce, 1984).

The models discussed above carry the implication that two different types of attentional mechanisms are required to resolve the effects of predictiveness and uncertainty. Esber and Haselgrove (2011), however, introduced a model which attempts to explain the effects of predictiveness and uncertainty with only one attentional mechanism. In their model, basic associative learning proceeds according to a summed prediction error, similar to that employed by Pearce and Hall (1980). Thus, an excitatory cue-outcome association is formed between a cue and an outcome when there is a positive prediction error between the two, and an excitatory cue-no outcome association is acquired when there is a negative prediction error between the two. The acquired salience of a cue (ε) is a function of the sum of its associations with outcomes and no-outcomes. Based on these assumptions, it should be clear why the salience of a partially reinforced cue will be higher than a continuously reinforced cue. In the case of partial reinforcement, the cue is associated with both an outcome and no-outcome and should therefore benefit from the sum of the associations between these two outcomes when salience is determined. In case of continuous reinforcement, the cue is only associated with one outcome, and should therefore only have a lower salience. Interestingly, the Esber-Haselgrove model, also uses this one mechanism to explain learned predictiveness. Although the irrelevant cues in this procedure are paired with two outcomes (and on the basis of the above discussion, we might imagine it would therefore have high salience), the opposite is in fact true. This follows because the irrelevant cue is trained in compound with cues that are better associates of their respective outcomes. The summed prediction errors used to drive learning will, therefore, ensure that the more predictive cues will out-compete the irrelevant cues for associative strength. Thus, even though the irrelevant cues are associated with two outcomes (and the predictive cues only associated with only one outcome), the strength of these associations for the irrelevant cues will be very weak.

Evidence supporting the effect of predictiveness and uncertainty on associability of cues has been shown in humans. Beesley, Nguyen, Pearson and Le Pelley (2015) manipulated the predictiveness of a stimulus-outcome association in a learned predictiveness task, where one group of participants would experience certain conditions (A always predicting Outcome 1 and B always predicting Outcome 2) and another group would experience uncertain conditions (A will predict Outcome 1 67% of the time and Outcome 2 33% of the time while B will predict Outcome 1 33% of the time and Outcome 2 67% of the time). They found that participants in the certain conditions learned the new stimulus-outcome association more accurately than participants in the uncertain conditions. While the eye movements of participants would focus on the uncertain stimuli by the end of Stage 1, learning of the new associations in Stage 2 were based on prior predictiveness of stimulus similar to those observed in the certain condition. Moreover, final causal judgement in the test stage indicated that learning was influenced by predictiveness and not uncertainty. These findings were replicated by Easdale, Le Pelley and Beesley (2019) who also recorded eye movements of participants in a learned predictiveness task. Their results showed a preference to attending to predictive stimuli compared to nonpredictive stimuli, and there was an overall bias in attention to uncertain stimuli during Stage 1.

Hybrid models such as Le Pelley (2004) and Pearce and Mackintosh (2010) that assume predictiveness and uncertainty are governed by separate systems explain this finding by assuming that uncertainty-based changes in attention are more sensitive to changes in context between training stages than predictive-based changes in attention. Meanwhile, a single process attention model like the Esber and Haselgrove (2010) model predicts that stimuli in a compound will compete for associative strength and a stimulus that is always paired with the same outcome will gain more associative strength than a stimulus paired with multiple outcomes. This would account for the results found in the certain condition group of Beesley et al. (2015) and Easdale et al. (2019). The Esber-Haselgrove model also predicts that when a stimulus is associated with multiple outcomes, it can still gain associative strength because of the summation process in the model, explaining the increase in overt attention to the uncertain cues in Stage 1. However, if the summation process is difficult to activate due to a change in context, it would explain why there was no carry over effect of uncertainty from Stage 1 to 2.

1.12: Summary of Chapter

To summarise, the Rescorla-Wagner model states that in order for learning to occur, the US must be surprising. It can be used to explain early cue interaction effects such as blocking, overshadowing and conditioned inhibition. However, it struggles to explain how change in the salience of the CS influences subsequent conditioning such as those found in latent inhibition and learned predictiveness. The Mackintosh theory states that more attention will be paid to the cues that have a history of being a good predictor and less attention to cues with a history of being a bad predictor, consistent with the predictiveness principle. Meanwhile, the Pearce-Hall model states that more attention would be paid to the cue that is followed by a surprising outcome, consistent with the uncertainty principle. The strengths and weaknesses of the Mackintosh theory and Pearce-Hall model were discussed. Hybrid models that were introduced to overcome the limitations of these traditional learning models were described and empirical evidence supporting these hybrid models were also discussed.

Chapter 2:

Introduction: Individual and Cultural Differences in Learning and Attention

2.1: Overview

This chapter will first explain what personality traits are and discuss how they are measured and studied. Next, a brief history of the conceptualisation of the Big 5 personality traits will be discussed. This chapter will then explain how the Big 5 personality traits have been linked to psychopathology such as schizophrenia and anxiety. After that, a brief history on the conceptualisation of schizotypy and trait anxiety will be discussed. It will then present evidence of the influences of schizotypy and anxiety on associative learning phenomena such as latent inhibition, blocking and learned predictiveness. Next, a comparison between learned predictiveness and the Wisconsin Card Sorting Task will be drawn to propose that the Big 5 can also play a role in associative learning. This chapter will also discuss the cultural differences in thinking and learning. Finally, this chapter will state the overall aims and rationale of this thesis.

Allport (1961) defined personality as "a dynamic organisation, inside the person, of psychophysical systems that create the person's characteristic patterns of behaviour, thoughts and feelings". There has been a recent interest in investigating the relationship between learning, attention and individual differences such as personality. A key motivation for this endeavour comes from how Maltby, Day and Macaskill (2017) define the *"dynamic organisation, inside the person"*, which they propose refers to a constant process of adapting to the changes in one's life such as ageing and various life experiences. On this basis and our earlier definition of learning, there should be significant relationships between individual differences and learning and one of the goals of this project is to investigate this relationship.

A trait is a "dimension of personality used to categorise people according to the degree to which they manifest a particular characteristic" (Burger, 1997). There are two underlying assumptions to trait theory; personality characteristics are relatively stable over (1) time and enduring across (2) different social contexts (Maltby et al., 2017).

2.2: The Big 5

Francis Galton (1884) was interested in the relationship between individual differences and language and applied the lexical hypothesis to the study of personality, proposing that important individual differences will eventually be encoded into language as single trait descriptors. Extending his work, Allport and Odbert (1936) selected nearly 18000 words from a dictionary with relevance to personality and personal behaviour and subsequently narrowed it down to 4500 words as descriptive of personality traits. Cattell (1957) further reduced this list to 46 words and by using factor analysis, 16 factors was identified to represent the basic structure of personality.

Goldberg (1981) reviewed a series of studies which employed the lexical hypothesis (Digman and Takemoto-Chock, 1981; Norman, 1963; Tupes and Christal, 1961) and consistently observed a five-factor structure of personality, consequently termed these factors (Surgency, Agreeableness, Dependability, Emotional Stability and Culture) the “Big 5”.

This five-factor model of personality was further validated using factor analysis by Costa and McCrae (1985) who called their factors openness, conscientiousness, extraversion, agreeableness and neuroticism. Costa and McCrae (1992) provided the following description of the five factor traits; individuals who score high in openness (O) would show attributes of intellectual curiosity and divergent thinking while someone who scores low in it tends to be more conventional in their thinking. Individuals with high conscientiousness (C) are well-organised in their plans and are determined to succeed in their life while those who are low in conscientiousness are more easily distracted from their goals. Meanwhile, extraverts (E) tend to be more sociable and assertive in their interactions while introverts tend to be more reserved and independent. Someone who scores high on agreeableness (A) would be more trusting and helpful while someone who scores low on agreeableness is sceptical and uncooperative. Finally, those who score highly in neuroticism (N) would be less able to regulate their emotions and experience more mood swings compared to those who score low in neuroticism are calmer and less susceptible to maladaptive emotional states. Costa and McCrae (1985*)* developed the NEO-PI and later introduced a revised version the NEO-PI-R (Costa and McCrae, 1992) to measure these five personality traits. There have also been other questionnaires which measure the Big 5 such as the Goldberg (1992) Transparent Bipolar Inventory and the Big 5 mini-markers (Thompson, 2008). The Big 5 personality traits have been replicated across various countries and have been shown to have good cross-cultural validity (Rolland, 2002).

Alongside the traditional five personality traits, researchers (Ashton, Lee and Son, 2000) identified a sixth factor and termed it the Honesty-Humility trait and introduced a new model of personality (HEXACO – Honesty-Humility, Emotionality, eXtraversion, Agreeableness, Conscientiousness and Openness). The HEXACO has been translated into many languages to be used in research and has shown to have good cross-cultural validity (Thielmann et al., 2020). However, the HEXACO has also received criticism where the Honesty-Humility trait is no different than the agreeableness within the original big 5 traits (Saucier, 2002).

2.3: Links to psychopathology

Eysenck and Eysenck (1985) proposed that an individual has three personality types (extraversion, neuroticism and psychoticism) and each of these traits represents a continuum in which someone could be placed, depending on the degree of characteristics they have.

Extraversion is placed on one end of the continuum while introversion is placed on the other end of the continuum and they define extroverts as sociable and impulsive individuals while introverts as quiet and introspective (Maltby et al., 2017). Eysenck (1965) defines neurotics as emotionally unstable individuals and that neurotic behaviours could be manifested in several ways. For example, some highly neurotic individuals experience irrational fears towards certain objects or people while others exhibit obsessive or impulsive behaviours, and these fears and anxieties displayed are disparate to reality. Neurotic individuals who lack fear and anxiety are categorised as psychopaths and these individuals show antisocial behaviours and show no remorse for their actions. Eysenck and Eysenck (1975) created the Eysenck Personality Questionnaire to measure these traits and claims that there is a link between the clinical states of neurosis and psychosis with the traits of neuroticism and psychoticism.

2.3.i: Schizophrenia

The DSM-V (APA, 2013) states that psychosis refers to the presence of hallucinations, delusions or both hallucinations and delusions, and is the defining feature of schizophrenia spectrum disorders (Arciniegas, 2015). The Global Burden of Diseases, Injuries, and Risk Factors Study 2017 (James et al., 2018) approximates 20 million people worldwide suffer from schizophrenia. While schizophrenia is considered a low prevalence disorder (see Baxter, Patton, Scott, Degenhardt and Whiteford, 2013 for details), it has been associated with significant health problems such as heart and liver disease that contribute to a higher premature mortality rate (Olfson, Gerhard, Huang, Crystal and Stroup, 2015), increased risk of suicide (Palmer, Pankratz and Bostwick, 2005), social impairments (Mascio et al., 2021) and economic burdens (see Chong et al., 2016 for review). Schizophrenia is also ranked the top 15 leading causes of disability in the world (Vos et al., 2017).

The term schizophrenia comes from the Greek words schizen (to split) and phren (soul, spirit or mind). Eugen Bleuler (1911) coined the concept of schizophrenia as the splitting of or break from reality caused by the disruption of the different functions of the mind, such that the way one feels and thinks no longer work with each other regularly (Carlson, 2013). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM) V (APA, 2013), schizophrenia is defined as having two or more of the following symptoms: delusions, hallucinations, disorganized speech/behaviour and negative symptoms such as diminished emotional expression. The DSM-V suggests that after a substantial length of time since the onset of these symptoms, when the social and occupational functioning of individuals has been significantly impaired, they can be diagnosed with schizophrenia.

There are three groups of symptoms that are used to identify schizophrenia: the positive symptoms, the negative symptoms and the cognitive symptoms. The positive symptoms consist of hallucinations and delusions. Hallucinations refer to perceptions occurring in the absence of any external or somatic stimuli (Arciniegas, 2015) while delusions are inaccurate and invalid judgements that mostly involve misinterpretation of experiences and perceptions (Grohol, 2013). Negative symptoms of schizophrenia are defined by the lack or absence of behaviours such as anhedonia and social withdrawal (NHS, 2019). The cognitive symptoms of schizophrenia include impaired attention, working memory and difficulties in learning and problem-solving (Bowie and Harvey, 2006).

2.3.ii: Comorbidity of schizophrenia and anxiety

Pokos and Castle (2006) found that more than half of patients experienced anxiety disorders before the onset of psychosis and Wilson, Yung and Morrison (2020) found a 29% comorbidity rate of anxiety in first-episode psychosis. Kiran and Chaudhury (2016) conducted a study to find the prevalence of different anxiety disorders in patients with schizophrenia and found that patients show a higher prevalence of anxiety disorders (45.16%) compared to the control population (16.12%). This is consistent with a review which found that 30%-62% of patients with schizophrenia exhibit comorbid anxiety disorders (see Howells, Kingdon and Baldwin, 2017 for review).

The World Health Organization estimates a global prevalence for anxiety disorders to be 3.6% in 2015 (WHO, 2017). Nochaiwong et al. (2021) was interested in whether the Covid-19 global pandemic impacted mental health issues in the general population and conducted a systematic review and meta-analysis with participants from 32 countries worldwide and found that the prevalence of anxiety is 26.9%. The DSM V (APA, 2013) defines generalized anxiety disorder as experiencing excessive anxiety and worry that is not focussed on a specific trigger (e.g., social situations, fear of specific events, fear of having panic attacks).

According to the DSM, symptoms of generalised anxiety disorder include restlessness, easily fatigued, difficulty concentrating, irritability, tensed muscles and sleep disturbances. To be diagnosed with anxiety, these symptoms experience is not better explained with other mental disorders, be attributed to substance abuse or another medical condition and social and occupational functioning have been significantly affected by the manifestations of symptoms. Anxiety disorders have been found to impact negatively on social and educational achievement throughout the lifespan (Van Ameringen, Mancini and Farvolden, 2003) and cognitive functions such as attention, learning and memory (Robinson, Vytal, Cornwell and Grillon, 2013).

2.4: Difficulties researching psychopathology

As mentioned above, schizophrenia plays a role in the impairment of attention and learning in individuals. Therefore, to investigate this relationship, many researchers have used associative learning tasks and the findings are mixed. Baruch, Hemsley and Gray (1988a) conducted a latent inhibition task on three populations: acute schizophrenia, chronic schizophrenia and healthy individuals. They found that the effects of latent inhibition are abolished in those with acute schizophrenia exhibiting positive symptoms but not in chronic schizophrenia and healthy samples. Rascle et al. (2001) found that not only those with acute schizophrenia show a reduction in latent inhibition, those with chronic schizophrenia show an enhancement in the effect. Furthermore, Cohen et al. (2004) demonstrated that an enhancement of latent inhibition is seen in chronic schizophrenia patients with high levels of negative symptoms, but they found that latent inhibition in individuals with high levels of positive symptoms was indistinguishable from controls. These studies suggest that effects of associative learning can be reduced, indistinguishable, and enhanced whilst inconsistently co-varying with symptomology and chronicity. Thus, to avoid confounds such as chronicity of illness and medication state, the assessment of schizotypy traits has been employed to assess schizophrenia via proxy.

2.4.i: Dimensional approach of schizotypy

Claridge (1997) identified two models of schizotypy: the quasi-dimensional and the fully dimensional. Meehl (1962) used the term "schizotaxia" to describe a genetic predisposition to schizophrenia and that schizotaxic individuals would either develop schizotypy or schizophrenia depending on the environment. The quasi-dimensional approach is more clinically oriented and is based on Meehl's concept of schizotaxia. In the fully dimensional approach, schizotypy is considered as a normally distributed dimension of personality within the general population (Claridge, 1995). The spectrum ranges from subclinical levels of psychotic-like symptoms in healthy individuals to proneness to psychosis and subsequently, the development of schizophrenia.

However, Claridge et al. (1996) claims that this approach is too simplistic and proposed four subscales that underlie schizotypy: unusual experiences (inclination to have unusual cognitive and perceptual experiences such as delusions and hallucinations), introvertive anhedonia (proneness to be withdrawn and be emotionally flat; deficiency to feel pleasure from stimulation), cognitive disorganization (in concentration, aberrant attention) and impulsive nonconformity (unstable moods and tendency to disregard rules and social norms).

Mason, Claridge and Jackson (1995) developed the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) to assess these four schizotypal traits. This questionnaire was expanded from 24 items to 104 items to improve its utility in clinical and experimental research (Mason and Claridge, 2006). Alternative questionnaires which also measure schizotypal traits such as the Schizotypal Personality Questionnaire (Raine, 1991) and the Hallucination Scale of Launay and Slade (Launay and Slade, 1981) have also been employed in research context, but a critique of these questionnaires is that they only measure the positive, negative and cognitive schizotypy trait unlike the O-LIFE which has a fourth dimension, impulsive nonconformity (Mason and Claridge, 2006). Mason (2015) agrees that this fourth dimension is not that relevant to schizophrenia, he argues that it is relevant to the psychosis-continuum sharing traits with Eysenck's psychoticism.

2.4.ii: Schizotypy and anxiety

Catell (1966) was the first to make a distinction between state and trait anxiety. State anxiety is defined as a temporary emotion that consists of tension, apprehension, nervousness and worry that fluctuates over time in various intensities (Spielberger and Rickman, 1990). They also defined trait anxiety as relatively stable individual differences in perceiving anxiety on a daily basis.

The Spielberger State-Trait Anxiety Inventory (STAI) (Spielberger, Gorsuch and Lushene, 1970) is a measure of anxiety that is widely used in research and consists of 40 items (20 items measuring how an individual is feeling at the moment – state anxiety, and 20 items measuring how an individual is feeling in general – trait anxiety). Finding that the STAI might be too time consuming, Marteau and Bekker (1992) developed a shortened version of the STAI consisting of 6 items which they observed is comparable in terms of reliability and validity to the full version. However, the STAI has been criticised to not be a measure of pure anxiety as it does not adequately discriminate between anxiety and depression symptomatology (see Grös, Antony, Simms and McCabe, 2007 for review). To overcome this limitation, Ree, MacLeod, French and Locke (2000) developed the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA) which replicates the core theoretical basis of the STAI by having separate state and trait scales. Each scale consists of 21 self-report items which are further separated by somatic and cognitive symptoms which are unique to anxiety and not depression.

Similar to its schizophrenia counterpart, Braunstein-Bercovitz, Rammsayer, Gibbons and Lubow (2002) found a relationship between schizotypy scale and anxiety scores. This effect was supported by Braunstein-Bercovitz (2000) who found a strong positive correlation between schizotypal score and trait anxiety.

2.4.iii: Schizotypy, anxiety and Big 5

While not many, there were also some studies that investigated the relationship between schizotypy and Big 5. For example, a study by Tien, Costa and Eaton (1992) found that openness and neuroticism were related to high schizotypy. West (1999) revealed that neuroticism is related to positive schizotypy while Ross, Lutz and Bailey (2002) showed that openness is positively correlated with positive schizotypy but negatively correlated with negative schizotypy. Asai, Sugimori, Bando and Tanno (2011) examined the relationship between the five-factor model and schizotypy using various questionnaires (schizotypy - O-LIFE, SPQ, SPQB; Big 5 - BFS, NEO-FFI). They found that all groups of questionnaires show that neuroticism was positively, and extraversion was negatively correlated with total schizotypy scores. However, except for one group, three of the other groups show A negatively and O positively correlated with total schizotypy scores.

When specifically looking at the Big 5 personality traits and the OLIFE, Asai et al. (2011) found that unusual experiences to have a positive relationship with O and N and a negative relationship with A; introvertive anhedonia to have a negative relationship with E; cognitive disorganisation to have a positive relationship with N and negative relationship with C; and impulsive nonconformity to have a positive relationship with O and E and a negative relationship with A and C.

In relation to anxiety, Patsiaouras, Chatzidimitriou, Charitonidis, Giota and Kokaridas (2017) observed a negative relationship between emotional stability and trait anxiety in athletes. Jylhä and Isometsä (2006) also found a positive relationship between neuroticism and trait anxiety while Moutafi, Furnham and Tsaousis (2006) found a positive relationship between neuroticism and state anxiety. While no study where schizotypy, Big 5 and anxiety can be found, the findings from this thesis can contribute to filling this gap in knowledge.

2.5: Relationship between schizotypy and associative learning

2.5.i: Latent Inhibition

Baruch, Hemsley and Gray (1988b) conducted an auditory latent inhibition task where the preexposed cue was a white noise. During the preexposure stage, participants in the pre-exposed group were presented with the white noise along with a list of nonsense syllables (recording A) while the non-preexposed group was just presented with a list of nonsense syllables (recording B); and they will be asked to count the number of times a certain syllable is presented as a masking task. During the test stage, participants in both groups were presented with recording A and whenever the white noise was presented, a score would be added onto a scoreboard. Participants were asked to raise their hand whenever they thought the scoreboard would be increased and the experiment ended after they reached the learning criterion. Baruch et al. found that participants in the preexposed group learned the white noise-score increment association slower than those in the nonpre-exposed group, demonstrating a latent inhibition effect. Their results also showed that latent inhibition was reduced in those who score high in schizotypy as measured by the psychoticism dimension of the Eysenck Personality Questionnaire (Eysenck and Eysenck, 1975).

Tsakanikos, Sversrup-Thygenson and Redd (2002) used a visual search task where participants had to locate a real word among a group of nonsense words. In the preexposure stage, only nonsense words were presented, and these words were surrounded by different coloured rings. A yellow ring would be included within the trials shown to the preexposed group but not in the non-preexposed group. In the test stage, the yellow ring was now then always presented with a real word. Their results revealed that accuracies in correct word identification for the non-preexposed group was greater than the pre-exposed group showing a latent inhibition effect and this effect is retarded in that scoring high in the schizotypal personality subscale of the Schizotypy Questionnaire (Claridge and Brok, 1984).

Gray, Fernandez, Williams, Ruddle and Snowden (2002) also employed a visual search task but used letters instead of words. Both the preexposed and non-preexposed groups were presented with three letters arranged to form a triangle and only the trigram for the preexposed group was surrounded by a white triangle. Participants were asked to choose a trigram and count how many times it was presented as a masking task. During the test stage, all the participants were presented with trigrams that are either surrounded by a triangle or a pentagon. There was also a counter at the top corner of the screen which incremented whenever a trigram and triangle was presented. Gray et al. (2002) found a latent inhibition effect where the non-preexposed group reached the learning criterion quicker than the preexposed group. Their results also indicated that participants who score high in the unusual experiences subscale of the OLIFE (Mason, Claridge and Jackson, 2006) show reduced latent inhibition.

Evans et al. (2007) also found a reduction in latent inhibition in participants who scored high in unusual experiences. They employed a letter prediction task which involved first presenting a series of letters including the preexposed stimulus in the preexposure stage and both the preexposed and non-preexposed stimuli in the test stage. Participants were tasked to press the spacebar whenever they think the letter X (always follows after the preexposed and non-preexposed stimuli) was going to appear or as quickly as they can when it appears. However, this was not replicated by Granger et al. (2016) who found an enhanced latent inhibition in participants high in unusual experiences.

2.5.ii: Blocking

Moran et al. (2003) used a Kamin blocking design within a maze-like game where participants were tasked to locate the "safe area" within the floor plan. They found that Kamin blocking was reduced in participants who were high in the unusual experiences and cognitive organization subscales of the OLIFE. This is inconsistent with Haselgrove and Evans (2010) who found a relationship with introvertive anhedonia and a reduction in blocking. In their study, they embedded a blocking design into a food allergist task where participants were asked to rate the likelihood of certain foods causing certain allergic reactions. They suggested that individuals high in introvertive anhedonia can form associations between events in the environment but because these individuals employ a nonselective learning approach, they do not demonstrate effects of blocking. However, despite replicating the design in Haselgrove and Evans (2010), Humpston, Evans, Teufel, Ihssen and Linden (2017) found no significant differences in blocking between participants high or low in positive and negative schizotypy.

2.5.iii: Learned Predictiveness

Le Pelley, Schidmt-Hansen, Harris, Lunter and Morris (2010) used the learned predictiveness design (Le Pelley and McLaren, 2003) in three cover stories: i) horticulturist developing new plant species; ii) researcher testing the side effects of vitamin pills; and iii) student in a new school guessing which student belongs to which society. Using the OLIFE, their results revealed those who scored high in the unusual experiences subscale show a reduced learned predictiveness effect (the ratings for relevant and irrelevant cues were comparable).

Haselgrove et al. (2016) aimed to determine whether low schizotypal individuals would show a greater overt attention towards relevant cues relative to irrelevant cues using a modified version of a learned predictiveness design where after Stage 1 training, Stage 2 was replaced with a dot-probe task, see Chapter 1.9 for detailed explanation of task. They measured overt attention towards previously relevant cues using eye-tracking and found that participants who scored low on the negative subscale of schizotypy (introvertive anhedonia) showed an explicit bias towards cues that were predictive of an outcome while high schizotypal participants maintained a similar attention to all cues, regardless of their relevance.

2.5.iv: Summary

To summarise, individuals high in schizotypy show a disruption in latent inhibition, blocking and learned predictiveness. However, in studies using the OLIFE to measure schizotypy, the pattern of disruption and specifically which subscale was responsible is inconsistent. Evans et al. (2007) found a reduced latent inhibition effect in individuals high in unusual experiences, but Granger et al. (2016) found an enhancement in the effect. In relation to blocking, Moran et al. (2003) found that those high in unusual experience and cognitive disorganization showed reduced blocking but Haselgrove and Evans (2010) found evidence for introvertive anhedonia playing a role in disrupting blocking. Lastly, Le Pelley et al. (2010) found that participants high in unusual experiences showed reduced learned predictiveness but Haselgrove et al. (2016) observed that attenuated learned predictiveness was shown in participants high in introvertive anhedonia.

2.6: Relationship between anxiety and associative learning

Compared to schizotypy, anxiety has received far less attention in the area of attentional learning. Despite that, there were a handful of studies studying the effects of anxiety in latent inhibition and blocking that could be found.

2.6.i: Latent Inhibition

Braunstein-Bercovitz (2000) conducted a latent inhibition task involving exposing participants in the preexposed group to both the masking stimuli (letters) and target stimuli (random shapes) during the preexposure stage while the participants in the non-preexposed group was only exposed to the masking stimuli. Participants were asked to determine if the letters presented were identical or different as part of the masking task. In the test stage, both groups were exposed to both masking and target stimuli and were told the counter would decrease if they responded in a certain way (i.e., press the spacebar when both the letters and shapes were presented). Participants in the non-preexposed group reached the learning criterion quicker than the preexposed group showing a latent inhibition effect. Braunstein-Bercovitz also correlated overall schizotypy score using the SPQ (Raine, 1991) with the trait subscale of the STAI (Spielberger et al., 1970) and found a strong positive correlation. Moreover, it was observed that participants high in trait anxiety showed an impairment in latent inhibition. Overall schizotypy score also correlated with impaired latent inhibition. However, when correlating latent inhibition with the anxiety-loaded (anxiety component of schizotypy) and perceptual-disorganization (schizophrenia-like component of schizotypy) subscale of the SPQ, it was found that the attenuation of latent inhibition was due to anxiety-loaded subscale and not the perceptual-disorganization subscale.

Employing the same task, Braunstein-Bercovitz, Dimentman-Ashkenazi and Lubow (2001) found that inducing stress in college students by using number tasks (high state anxiety), caused students to show impaired latent inhibition compared to students who had low state anxiety. However, in a letter prediction task, Granger (2017) demonstrated that neither state nor trait anxiety influenced effects of latent inhibition or mediated the effect of schizotypy in learning about pre-exposed stimuli.

2.6.ii: Blocking

Boddez, Verrliet, Baeyens Lauwers, Hermans and Beckers (2012) conducted a blocking study employing a human aversive conditioning task where they asked participants to discover the switch functions on a “shock machine”, where different switches would deliver different levels of shocks to participants’ wrist. They found that participants high in trait anxiety gave higher shock expectancy ratings to the blocked stimulus. They argue that highly anxious individuals have a tendency to generalise their fear and thus, provide higher ratings to the most likely cause of danger regardless of prior selective learning. The deficit in blocking is therefore caused by this selective threat appraisal. Moreover, Dawes (2016) replicated the blocking task from Haselgrove and Evans (2010) and found an attenuation in blocking in participants high in trait anxiety, specifically a reduction in learning about the relevant stimuli, and also suggested that the role of anxiety was due to a threat-avoidance mechanism.

2.7: Relationships between the Big 5 and learning

Despite being one of the most prominent personality trait theories, relatively few studies on associative learning could be found that have tried to assess their relationship with the Big 5 personality traits. Wuthrich and Bates (2001) used a similar between-subjects auditory latent inhibition task as described in Baruch et al. (1988b) and found no association between psychoticism (P) and the Big 5 personality traits with latent inhibition. However, Peterson and Carson (2000) used the same auditory task and found that participants high in openness showed faster learning about the pre-exposed cues and this consequently, caused latent inhibition to be reduced.

Jones, Gray and Hemsley (1993) measured the EPQ traits of agoraphobics and found an increased N and a lower P. They presented a Kamin blocking task where the preexposed group were presented with a random series of coloured squares. The yellow square always followed after a blue square and would not appear otherwise. The non-preexposed group was presented with a random series of coloured triangles with yellow squares interspersed during Stage 1. In Stage 2, both groups of participants were presented with a compound (blue square + white square) which was always followed by a yellow square. They were asked to respond when they think the yellow square would be presented and moved onto the following stage after reaching the learning criterion. In the third stage, participants were then only presented with the white square followed by the yellow square. Participants were again asked to respond when they thought the yellow square would be presented and a blocking effect was observed if participants in the preexposed group took longer to reach the learning criterion compared to the non-preexposed group. Their results revealed an enhanced Kamin blocking effect in agoraphobics but no direct evidence of N and P playing a role in their findings.

2.7.i: Wisconsin Card Sorting Task (WCST)

Executive function (EF) tasks such as the WCST (Berg, 1948) can be used as an indirect comparison with a learned predictiveness task. The WCST falls under the cognitive flexibility (ability to switch between multiple concepts simultaneously) dimension of EF and is related to the formation of concepts, set shifting, perseverative thinking and categorizing (Miyake et al., 2000).

In a WCST task, participants are asked to categorise cards either by colour, shape or number of designs on the face of the cards. Participants are not told which criteria to follow but instead are given feedback whenever they manage to sort according to a criterion of the experimenter's choice. After making 10 consecutive correct classifications, the experimenter will move onto the next criterion. This change in criterion will then require participants to shift to a new set of rules and the difficulty to set shift is indicated by preservative errors (how many trials does it take until participants obtain 10 consecutive correct responses).

With relation to a typical learned predictiveness, Stage 1 is comparable to when participants are asked to learn a rule on how to sort the cards. As immediate feedback was given in both tasks, participants will eventually learn the correct response. In Stage 2 of a learned predictiveness task, participants are given new compounds and outcomes, and this is similar to the set shifting component in the WCST. Now participants must learn a new set of rules and respond appropriately.

Murdock, Oddi and Bridgett (2013) examined the relationship between different aspects of EF and the Big 5 personality traits and found that openness was positively associated with cognitive flexibility as measured by the WCST. These results are further supported by Yilmaz and Kafadar (2018) who also found a positive relationship between openness and WCST performance. Despite these findings, cognitive flexibility has also been associated with extraversion (Campbell, Davalos, McCabe and Troup, 2011), agreeableness and conscientiousness (Jensen-Campbell, Rosselli, Workman, Santisi, Rios and Bojan, 2002).

Performance in WCST has also been linked with schizotypy and anxiety. Lenzenweger and Korfine (1994) found that participants high in schizotypy showed poorer performance in WCST relative to controls and state anxiety was not associated with performance. Topçuoğlu, Fistikci, EkİncĪ, Gönentür, and Agouridas (2009) found that trait anxiety as measured by the STAI negatively correlated with number of correct responses and positively correlated with number of errors. This is consistent with Edwards, Edwards and Lyvers (2015) who found poorer performance associated with trait anxiety (as measured using the STICSA) independent of situational stress.

Granger (2017) used a single cue learned predictiveness task where participants were asked to predict which two background colours (outcome) a fictional company (stimulus) used as their business cards. In Stage 1, companies A and D were consistently paired with a pink background while companies B and C were consistently paired with an orange background, making companies A to D relevant stimuli. Companies X and Y were paired equally with both pink and orange stimuli making them the irrelevant stimuli. In Stage 2, participants were asked to rate the company profitability. Companies A, C and X were consistently paired with making the same amount of profit while companies B, D and Y were consistently paired with making the same amount of loss.

If there was an effect of learned predictiveness, participants would learn the associations of companies A to D (previously relevant stimuli) quicker than companies X and Y (previously irrelevant stimuli). The findings revealed that participants low in state anxiety (measured by the STICSA) were faster in learning about the relevant company-profitability associations than the irrelevant company-profitability associations while those high in state anxiety showed no difference.

2.7.ii: Summary

It can be seen from the above sections that there is a relationship between schizotypy, anxiety and the Big 5 personality traits. However, compared to schizotypy, there is a gap in knowledge in how anxiety and even more so for the Big 5 to play a role in attentional learning. There is evidence in both state and trait anxiety in impairing latent inhibition (Braunstein-Bercovitz et al., 2000; 2001) and blocking (Bodez et al., 2012; Dawes, 2016). Moreover, Granger (2017) found that while participants low in state anxiety performed better in a learned predictiveness task, those high in state anxiety showed no difference in learning about the relevant and irrelevant stimuli. The evidence highlighting a relationship between the Big 5 personality traits and attentional learning is scarce. Only one direct piece of evidence can be found where participants high in openness show a reduction in latent inhibition (Peterson and Carson, 2000).

However, we can draw parallels from the learned predictiveness task and the WCST where in both tasks, participants have to learn a set of contingencies in Stage 1 and in Stage 2, these contingencies will be switched, and participants have to learn the new rules and respond appropriately. Moreover, there is also evidence that performance in WCST is impaired in those high in schizotypy (Lenzenweger and Korfine, 1994) and trait anxiety (Edwards et al., 2015;

Topçuoğlu et al., 2009). Therefore, it is possible to hypothesize that the Big 5 personality traits can also play a role in learned predictiveness.

2.8: Cultural differences in learning

2.8.i: Definition of culture

The works of classical British empiricist John Locke (1632-1704) and David Hume (1711-1776) suggest that how one thinks is universal in individuals. However, the evidence presented above shows that personality traits challenge this view as learning about a cue-outcome relationship is attenuated in an individual high in schizotypy compared to individuals low in schizotypy. Similarly, individuals with varying levels of trait anxiety and the different dimensions of the Big 5 personality traits can show differences in learning.

For the past few decades, research has shown that culture plays a factor in how people learn and think (Lehman, Chiu and Schaller, 2004; Nisbett, Peng, Choi and Norenzayan (2001). Culture consists of “knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society” (Tylor, 1889). Within the field of cultural psychology, *culture* is regarded as an internal component (innate factors) rather than external (environmental circumstances) and is a way of knowing and construing about the world through a process of interactions, where these construals acquire a degree of shared meaning that generate a set of everyday practices (see Greenfield, 2000 for review). Taking inspiration from Mesoudi and Thornton’s (2018) formalised model of cumulative culture, Heyes (2020) defines culture as a (1) change in behaviour due to nonsocial learning and (2) subsequently, this new learning transferring to other individuals or groups via social learning where (3) this newly learned behaviour causes an improvement in performance, and finally these three steps are repeated to generate gradual improvement of behaviour over time.

2.8.ii: Individualism and collectivism

Dutch cultural psychologist Gerard Hendrik Hofstede's (1928-2020) research was mainly focussed on the cultural differences between nations. During his time at IBM International, he surveyed employees from 64 countries and later sampled students from 23 countries, consumers from 15 countries, airline pilots from 23 countries and civil service managers from 14 countries (Maltby et al., 2017). He conducted a national level factor analysis and identified six dimensions: i) power distance - the extent to which the less powerful members of groups accept and expect power to be distributed unequally; ii) uncertainty avoidance - deals with society's acceptance for ambiguity; iii) individualism - degree to which people in a society are integrated into group and at the opposite end of this spectrum is collectivism; iv) masculinity/femininity - distribution of values between gender; v) long term versus short term orientation - the long term pole includes values such as perseverance, thrift and humility while the short term pole includes values such as respecting social obligation, respect for tradition and personal steadiness; vi) indulgence versus restraint - indulgent societies allow relatively free gratification of basic human natures while restraint societies controls these gratifications (Hofstede et al., 1980; 2011). The focus of this thesis will be on the individualism/collectivism dimension.

It can be said that *individualistic cultures* possess a relatively *independent view* of the self while *collectivistic culture* possess a relatively *interdependent view* of the self and these cultural differences resulted in divergent cognitive processes (Slabu, Lenton, Sedikides and Bruder, 2014). For example, the individualistic culture has been suggested to hold a more analytical thinking style while the collectivistic culture holds a more holistic thinking style (Choi, Koo and Choi, 2007; Ji, Peng and Nisbett, 2000; Matsumoto and Yoo, 2006). Nisbett et al. (2001) argues the difference in thinking style stems from the ancient Greek and ancient Chinese civilizations whose social and cognitive differences have been passed down culturally to their modern descendants. They also suggested that the ancient Greek civilization gave rise to the European and post-Columbian American civilization while the ancient Chinese civilization gave rise to the East Asia civilizations including Japan and Korea as well as greatly influenced the nations of Southeast Asia. This is consistent with how European and North American countries are generally classified as individualistic countries and countries within the Asian continent are generally classified as collectivistic countries within the Hofstede database.

Within ancient Greece, the Athenian Socrates was a public figure and central participant in the intellectual debates so common in the city. He nurtured his students to have dialectic arguments and the drawing of distinctions (Hornblower, Spawforth and Eidinow, 2012). He thus encouraged using various ways of reasoning and discussion to uncover the truth. This mindset evolved over time within the western civilization (individualistic culture), where individuals would rely on rules and formal logic to solve problems (Lehman, et al., 2004). Accordingly, the individualistic culture would tend to focus on attributes of the object to assign it to categories and have a preference for using rules about the categories to explain and predict the object's behaviour (Nisbett et al., 2001; Nisbett and Masuda, 2003).

In contrast, the ancient Chinese civilization discouraged any form of confrontation such as debate within the social group (Nisbett et al., 2001). Moreover, it was also revealed that the Chinese never made a formal model of the natural world but proceeded with intuition and empiricism. Until the modern day, the Chinese civilization (collectivistic culture) relied on holistic information processing (Lehman et al. 2004). Consequently, the collectivistic culture would be better at detecting covariations and have stronger expectations that outcomes will change in the future (Ji et al., 2000).

2.8.iii: Empirical evidence

The dissociation of *attention* between cultures, where the individualistic culture thinks analytically while the collectivistic culture thinks holistically, is supported by Masuda and Nisbett (2001) who showed European American and Japanese participants cartoons of underwater scenes containing fish and other smaller background items. They asked participants to describe the scenes and found that American participants' descriptions are more object oriented (e.g., fish) while the Japanese participants' descriptions focussed on both objects in the foreground and background. In a subsequent memory task, they found that Japanese participants recalled more background objects than the American participants. This tendency for Western culture to be more object-oriented and attend less to contextual stimuli is further supported by Chua, Boland and Nisbett (2005) who found that North American participants fixated more on the focal objects in pictures while the Chinese participants made more saccadic eye movement towards the background.

Ji et al. (2000) used a Rod and Frame task which involved presenting participants with a line (rod) at the end a box (frame) where both these objects can be rotated independently. They were tasked to judge when the rod was positioned vertically regardless of the orientation of the frame. Their results show that American students compared to Chinese students made fewer errors and spent less time on the task suggesting they were less field dependent, which is consistent with the idea that they pay more attention to the object itself rather than the relationship between the object and the field. Consistent with these findings, a study by Alotaibi, Underwood and Smith

(2017) compared eye movements in a visual search task and found that participants from a collectivistic culture (Saudi Arabia) show longer search times and less efficient search paths compared to participants from an individualistic culture (UK). Most studies studying cultural differences often use participants from North America as representatives of an individualistic culture and China/Japan/Korea as representatives of a collectivistic culture. Thus, on top of supporting previous findings, Alotaibi et al.'s (2017) results provide evidence that holistic and analytical thinking can be applied more generally to collectivistic and individualistic cultures around the world respectively.

Norenzayan, Smith, Kim and Nisbett (2002) also demonstrated how cultural differences in *thinking styles* have an effect on psychological processes and behaviours between the Western and East Asian population. They presented Korean and European American students a set of arguments and asked them to evaluate whether the conclusions drawn from them followed the premise of the arguments logically. Their results show that Korean students tended to make more judgment errors than American students when the conclusions of the arguments were logically valid but intuitively implausible. Norenzayan et al. (2002) explained their findings by arguing that those in Western cultures use formal logical rules in reasoning while those in East Asian cultures employ a more intuitive and experience-based reasoning technique.

Indeed, this is supported by Peng and Nisbett (1999: see for review) who found that Asians prefer a more dialectic approach to thinking, where multiple perspectives are considerate and a "middle-way" or compromise is sought to resolve conflicting arguments. Lun, Fisher and Ward (2010) corroborated this claim when they asked New Zealand European and Chinese students to complete two critical thinking measures and found that students from New Zealand performed better at both tasks than the Chinese students. Their findings also revealed that Chinese students rely more on dialectic thinking approaches when solving complex problems.

Studies have found that *language* used in different cultures can also further impact attention allocation (Rhode, Voyer and Gleibs, 2016; Senzaki, Masuda, Takada and Okada, 2016; Tajima and Duffield, 2012). Specifically, languages such as Japanese and Korean that incorporate an honorific system may require speakers to habitually pay more attention to surrounding situations and relationships and therefore, transfer across to non-linguistic settings (Rhode et al. 2016). In a picture description task, Tajima and Duffield (2012) found that compared to the Chinese and English native speakers, Japanese native speakers reported more ground information followed by focal information and in the recall task, they accurately remembered more background details. Japanese and Korean participants are commonly grouped together with Chinese participants because they share similar Confucian heritage (Gupta, Haranges and Dorfman, 2002) and Tajima and Duffield's findings bring significant implications where holistic attentional bias may not be consistent across East Asian cultures.

Moreover, these linguistic influences on attentional biases have been shown to grow stronger with *age* (Senzaki et al., 2016). They asked two age groups of Canadian and Japanese children (4-6 and 7-9 years old) to describe the scene of a short animation and found no difference between cultures although children were starting to show signs of different modes of attention by age 9. When paired with their parents in the same task, Canadian parents described the scene using a selective mode of attention while Japanese parents described the scene using a context-specific mode of attention. Children from the 7-9 age group now showed a cultural difference mirroring their parents' descriptions but there was still no difference in the 4-6 age group.

As discussed by the studies above, culture plays a clear role in how an individual learns and allocates attention. However, there have been no studies which compare cultural differences with associative learning effects. This is an important omission given (1) personality traits can mediate attentional learning and (b) personality traits differ between collectivistic and individualistic cultures. While individual differences such as personality traits are still relatively newly employed in the field, it is unfortunate that cultural differences are completely overlooked and based on the evidence reviewed, it may provide an alternate account of the mixed findings.

While it is not a direct comparison, a study by Ji et al. (2000) may provide a starting point on how culture may impact upon associative learning. In their study, they manipulated the covariation between two sets of stimuli and found that Taiwanese Chinese students were better and more sensitive at detecting the relationships between stimuli and provided more confident causal judgement ratings than the American students. The Chinese students were also less susceptible to primacy bias, as opposed to the American students who employed a heuristic primacy effect where they tend to better remember the first piece of information they encountered rather than the information they received later on. Even with the findings from Ji et al., along with the studies described earlier on variations in attentional allocation, suggest a potential difference in learned variations in attention, to date there has been no study of cultural differences in learning and attention.

2.9: Rationale and aims

While the specific aims of each study will be presented within the chapter introductions, this section will discuss the overall three main goals of the thesis.

From the literature presented above, there seems to be a heavy focus in the use of latent inhibition and blocking in order to understand the dysfunction in attention found in high schizotypy. The use of Kamin blocking and latent inhibition as an index of learned attention is understandable as both tasks (1) have motivated the development of attentional models of learning and (2) are associated with measures of attention beyond associability change (Le Pelley et al., 2014; Hills et al., 2021*)*. However, either or both of these tasks may be multiply determined – both for example can be explained in terms of a basic error correction mechanism (e.g., Wagner, 1978). Furthermore, Le Pelley et al. (2010) argue that latent inhibition and blocking could also have as their basis inferential reasoning. It is therefore desirable to examine the extent to which these tasks, and others which purport to measure learned attention (e.g., learned predictiveness) share commonalities. Most of the aforementioned studies have only tested each learning phenomenon by itself and concluded that an impairment in them suggests a deficit in selective attention in schizophrenia patients and highly schizotypal individuals. Only two studies that tested two learning phenomena within the same person could be found (Granger et al., 2019; Serra et al., 2001). Serra et al. found both disrupted Kamin blocking and latent inhibition within schizophrenia patients, but Granger et al. did not find a correlation between the two effects. In addition, Serra et al. found that individuals high in schizotypy show an attenuation to latent inhibition but not in blocking.

The first goal of this thesis thus, was to determine if two different associative learning effects can be found within the same individual, namely learned predictiveness and blocking and more importantly whether the magnitudes of these two phenomena correlate with each other. Furthermore, there are substantially fewer studies that have examined personality characteristics that are associated with blocking and learned predictiveness procedures in the published literature relative to latent inhibition thus, this thesis aimed to fill that gap. Helpfully, there are food allergist task counterpart tasks for both learned predictiveness and blocking. Therefore, despite there being other cover stories that can be used, the studies in this thesis will use the food allergist task. Consequently, this enables their magnitude to be compared and be a better measure of attention.

The second goal of this is to investigate the extent to which personality traits predict the effects of learning. There is a general consensus that unusual experiences and introvertive anhedonia of the schizotypy dimensions to play a role in the attenuation of latent inhibition (Granger, Prados and Young, 2012; Granger et al., 2016), blocking (Haselgrove and Evans, 2010) and learned predictiveness (Haselgrove et al., 2016) but Moran et al. (2003) have found evidence of cognitive disorganization. In terms of trait anxiety, evidence of it mediating latent inhibition (Braunstein-Bercovitz, 2000) and blocking (Boddez et al., 2011) are scarce. To the best of this author's effort, none could be found for learned predictiveness, but Granger (2017) found disrupted learned predictiveness in participants with high state anxiety. However, performance of the WCST (indirect comparison for learned predictiveness) has been found to be impaired by high levels of trait anxiety (Topçuoğlu et al., 2009). Despite the Big 5 being perhaps the most widely used measure of personality, there are barely any studies that explored its effects on learning. Jones et al. (1993) found an indirect effect of neuroticism and psychoticism among agoraphobic who demonstrated enhanced Kamin blocking while Wuthrich and Bates (2001) found no effect of the Big 5 on latent inhibition. Once again, none could be found for learned predictiveness but performance on WCST has been linked to openness, extraversion and agreeableness (Campbell et al., 2011; Jensen-Campbell, 2002; Yilmaz and Kafadar, 2018). Therefore, this thesis also aims to fill the gap in relation to the Big 5 personality traits and at the same time, replicate previous findings where schizotypy and anxiety traits mediated learning of cue-outcome relationships.

The third goal of this thesis is to determine if culture moderates the allocation of attention during learning. Culture has been shown to influence how someone perceives the world and consequently behave accordingly, which could therefore, provide an alternate account for the mixed results in previous studies. Thus, this study plans to recruit participants from individualistic and collectivistic nations to compare and contrast any differences in attention-driven learning. In conclusion, the studies carried out from these three main goals will provide a more comprehensive understanding of the relationship between attentional learning by including a broader set of measures of individual differences; and by conducting these studies within a cultural differences context, novel insights into the mixed evidence found in attentional learning can be explored further.

Chapter 3:

Blocking and Learned Predictiveness

3.1: Study 1

3.1.i: Introduction

Blocking refers to the failure to learn an association between a stimulus and an outcome when the stimulus is accompanied by another stimulus that itself has previously been established as a predictor of the same outcome. Kamin (1969) conducted a now classic study comprising three stages and two groups of rats. During Stage 1, Group 1 received 16 trials where a noise (CS) was paired with a foot shock (US). During Stage 2, both groups then received 8 trials of a compound CS (light + noise) paired with a foot shock. In the test stage, only light was presented by itself. If there was a blocking effect, learning of the noise → shock association in Group 2 would be better than in Group 1. Indeed, he found that the rats in the former group showed good conditioning, while the latter group showed no evidence of conditioning towards light. Besides rats, blocking has also been demonstrated in rabbits (Betts et al., 1996), pigeons (Leyland and Mackintosh, 1978), and molluscs (Sahley et al., 1981) and has been replicated in a variety of experimental procedures such as taste-aversion (Gallo and Cándido, 1995) and fear conditioning (Li and McNally, 2014). Blocking has also been demonstrated in humans (Haselgrove and Evans, 2010; Le Pelley et al., 2005, 2014; Moran et al., 2003).

In a food allergist task, participants are presented with a fictitious patient who after eating certain foods experiences certain allergic reactions, and at the end of the task, participants are asked to rate the likelihood of certain foods causing certain allergies. Le Pelley et al. (2005) found that participants rated a food item (B) as likely to cause an allergic reaction if it was previously compounded with another food item (A) that also caused an allergic reaction (AB+). However, if

A was previously presented by itself and caused an allergic reaction (A+), participants showed little learning about B, demonstrating that learning about A "blocked" learning about B.

According to the Rescorla-Wagner (1972) model, see Equation 1 (Chapter 1), when a CS (A) is first paired with a US (shock), an association between A and the US will be acquired that is proportional to the discrepancy between $V_{A.}$ With additional training, this discrepancy will get smaller and smaller until ultimately the asymptote (λ) of conditioning supported by the US is reached and no further learning will take place. When another CS (B) is paired with A, and this compound is followed with the presentation of the US (shock), the model predicts that the error term will be zero, again supporting no learning to either A, or the added CS, B. Later testing will therefore show little to no learning of the association between B and the US.

Alternatively, the Mackintosh (1975a) theory, see Equation 2, proposes that on the first compound trial with A and B in Stage 2, the attention paid towards B will be relatively higher due to its novelty, thus permitting it to gain associative strength. However, during this trial, it will be discovered that light (B) is a much worse predictor of the US (shock) than A (i.e., its prediction error is larger) and consequently the associability of B will fall, limiting further gains in associative strength. This is in contrast with the Rescorla-Wagner model which predicts that the US is fully predicted on the first compound trial and any learning of the newly added CS would not be possible.

Support to Mackintosh's (1975) account of blocking comes from Dickinson, Hall and Mackintosh (1976). In Stage 1 of this experiment, two groups of rats were conditioned with a light followed by two shocks separated by an interval of 8 seconds. In Stage 2, both groups were conditioned with light and clicker. However, in Group 1, only one shock was given while in Group 2, the rats were continually given two shocks separated by 8 seconds. Group 2 follows a typical blocking design and therefore, Dickinson et al.'s results showed that at test, the rats did not show much conditioning towards the clicker. Importantly, their results revealed that the rats in Group 1 showed strong conditioning towards the clicker, a so-called unblocking effect. They explained their results were due to the surprising omission of the second shock in Stage 2. Since the Mackintosh theory predicts that conditioning of the newly added element to the compound can proceed normally on the first trial, and when it does not signal any change in the outcome that was already being predicted by the pretrained element, there will be a decline in its associability in Group 2. However, since there was an omission of shock when the clicker is compounded with the light in Group 1, this surprising event maintained the rats' attention to the clicker and therefore, they successfully learned the association between the clicker and shock. The saliency of a CS influencing blocking has also been shown in humans (Le Pelley et al., 2005).

Learned predictiveness refers to a bias in learning about stimuli that have, in the past, been established as good predictors of different outcomes to those that are currently being learned about. A typical learned predictiveness task is usually conducted under the guise of cover stories such as the food allergist task (Le Pelley and McLaren, 2003), the horticulturist task (Morris, Griffitsh, Le Pelley and Weickert, 2013) or even determining which society a student belongs to (Le Pelley et al., 2010) and consists of three stages, Stage 1, Stage 2 and test stage. In Stage 1, A and C reliably predict Outcome 1 while B and D reliably predicted Outcome 2, see Table 3.1 (Learned Predictiveness). According to the Mackintosh theory, the prediction error for A to D would decrease. W/X/Y/Z were paired equally as often with Outcomes 1 and 2 and following Equation 2, the prediction error for W to Z would increase. Since the prediction error of W to Z is greater than the prediction error of A to D (Chapter 1: Equation 2b), the change in associative strength will be negative and the associability of W to Z will decrease.

In Stage 2, participants were provided with a new learning context where the previously relevant predictors (A/B/C/D) were paired with previously irrelevant predictors (W/X/Y/Z) in never-before-seen compounds (AW/BZ/CX/DY) and these compounds was paired with new Outcomes 3 and 4. Now, A/W and C/X have an equal probability of signalling Outcome 3 and B/Z and D/Y have an equal probability of signalling Outcome 4. To determine if prior knowledge of relevance learned in Stage 1 will bias learning of the new stimuli-outcome association, participants were asked to rate the likelihood of the predictors causing the outcomes. Studies (Haselgrove et al., 2016; Le Pelley and McLaren, 2003; Morris et al., 2013) have found that participants rate the likelihood of the relevant predictors causing Outcome 3 and 4 higher than the irrelevant predictors despite both predictors having an equal probability of signalling these outcomes in Stage 2.

As the compounds in Stage 2 are novel, the Mackintosh theory predicts that the attention paid to both stimuli of a compound (e.g., AW) will be relatively high initially. However, as attention from Stage 1 to A will be higher than to where there will be an imbalance in the amount of attention distributed to these two stimuli, consequently, participants should provide higher ratings for the relevant stimuli compared to the irrelevant stimuli, which is precisely what is observed.

To the extent that both blocking and learned predictiveness can be explained using the Mackintosh theory suggests that both effects may have, at least in part, a common attentional component, which is why both phenomena have been used to investigate the learning and attentional impairments in schizotypal individuals. The findings in previous studies have revealed that individuals high in schizotypy and anxiety show reduced blocking (Dawes, 2016; Haselgrove and Evans, 2010; Moran et al., 2003) and learned predictiveness (Granger, 2017; Haselgrove et al., 2016; Le Pelley, Schmidt-Hansen, Harris, Lunter and Morris, 2010). However, the specific schizotypy dimensions that have been observed to attenuate learning have been mixed. Unusual experiences and cognitive disorganization have been shown to be associated with reduced Kamin blocking (Moran et al., 2003) and introvertive anhedonia (Haselgrove and Evans, 2010). Dawes (2016) also found an effect of anxiety on the impairment of blocking. Additionally, reduced learned predictiveness has been observed in individuals high in unusual experiences (Le Pelley et al., 2010) and introvertive anhedonia (Haselgrove et al., 2016). However, Granger (2017) showed no effect of schizotypy on learned predictiveness but found an effect of anxiety.

Even though there is a reasonable consensus that schizotypy can mediate the attenuation of blocking and learned predictiveness, specifically which dimension for each of these phenomena has yet to be determined, particularly when the two tasks are compared under comparable circumstances. A method to achieve this could be to test both effects in a within-subjects design and determine if the magnitude of the effects are comparable and subsequently use them to investigate their relationship with personality traits. Serra, Jones, Toone and Gray (2001) and Granger et al. (2019) observed impaired latent inhibition and blocking within the same participant, but the two effects did not show a correlation. This could be due to the different tasks employed to generate both effects. While there have not been studies comparing both blocking and learned predictiveness, it is possible to embed the design into a food allergist task, as both phenomena have been revealed using this procedure (Haselgrove and Evans, 2010; Le Pelley and McLaren, 2003), and both phenomena involve two stages of training, followed by a final test. Therefore, the goal of this study was to create a procedure that could generate both learned predictiveness and blocking and subsequently, a method to compare the magnitudes of both effects. This can then answer whether blocking and learned predictiveness uses the same attentional processes which is theoretically interesting and consequently, be able to further validate any possible effects of personality traits and culture on attention and learning.

The experimental design used will be adapted from the blocking task used by Haselgrove and Evans (2010), as it has been successfully demonstrated the blocking effect in humans, and the learned predictiveness task from Le Pelley and McLaren (2003), see Table 3.1 for full design. In a deviation from Le Pelley and McLaren (2003), we tested the relevant and irrelevant stimuli in isolation, rather than in compound in order to make the design of the final test stage for learned predictiveness and blocking (which traditionally test cues alone) more comparable. The reason for determining if both blocking and learned predictiveness can be observed in the same experimental procedure is so that at a later time, this procedure can be used for the purpose of investigating the effect of personality traits and cultural orientation. It was predicted that participants would provide higher ratings for relevant stimuli than irrelevant stimuli, demonstrating a learned predictiveness effect, and higher ratings for control stimuli than blocked stimuli, demonstrating a blocking effect.

3.1.ii: Methods

3.1.ii.a: Design

This study used a fully within-subjects design. The manipulated variable was the relevance of the stimuli (learned predictiveness – relevant (A, B, C, D) and irrelevant (W, X, Y, Z); blocking – control (Q, R) and blocked (P, S) and the dependent variable was the rating scores obtained from the test phase. It was expected that when the stimuli are good predictors (relevant/control) of an outcome, the rating scores of the stimuli at test phase would be higher than when the stimuli are bad predictors (irrelevant/blocked).

The number of trials in this design was determined by the number of trials in Stage 1 of both the learned predictiveness and blocking task. Le Pelley and McLaren (2003) had 14 trials while Haselgrove and Evans (2010) had 10 trials. We therefore took the average between the two tasks and used 12 trials for Stage 1. In Stage 2, we just halved our trials.

Table 3.1: Study 1 experimental design. Letters A to Z represent the different food items (stimuli)

Stage 1	**Stage 2**	**Test**
Learned Predictiveness		
AX - O1	AW - O3	A
AY -O1	BZ - O4	B
BX - O2	CX - O3	C
BY - O2	DY - O4	D
CW - O1		W
CZ - O1		X
DW - O2		Y
DZ - O2		Z
Blocking		
E - O3	EP - O3	P
F - O3	FQ - O4	Q
G - O4	GR - O3	R
H - O4	HS - O4	S

3.1.ii.b: Participants

42 University of Nottingham students participated in this study. There were 21 males and 22 females. The age of the participants ranged from 18 to 34 years old, (M = 23, SD = 4.49).

Participants were recruited through the school's Research Participation Scheme, a social media platform (Facebook), recruitment posters and word of mouth. Participants had either normal or corrected-to-normal vision. This study along with the rest of the studies in this thesis was conducted according to the ethics guideline of the University of Nottingham School of Psychology and GDPR regulations.

3.1.ii.c: Apparatus

An iMac with a 21.5-inch screen used Psychopy (version 1.85.2; Peirce, 2019) to present stimuli, record responses and control experimental events. Participants' responses were recorded using a wired Apple mouse. The data obtained was analysed using Microsoft Excel, SPSS and Jamovi.

3.1.ii.d: Materials

The 16 foods used were apple, orange, grape, biscuit, cupcake, salmon, cod, tuna, lamb, ham, chicken, steak, potato, carrot, broccoli, pea. The images of the food words were 6 cm (width) x 2.5 cm (height). 8 foods were used for the blocking stimuli and 8 foods were used for the learned predictiveness stimuli. The four types of allergic reactions were: itch, dizziness, nausea and sweating. These food items were presented on top of the screen while the allergies were presented at the bottom in a form of a rating scale, refer to Figure 3.2. The stimuli (16 food items) were assigned to the letters via the Latin square counterbalancing method. For example, broccoli would be A in one iteration and can be B in the second iteration and C in the third iteration until it has cycled through all 16 letters as seen in the design table. This means that there are 16 counterbalanced combinations groups and participants are randomly assigned to one of the sixteen groups.

3.1.ii.e: Procedure

Participants were tested individually in the university's computer lab within the School of Psychology. An information sheet containing brief information about the experiment was handed to the participants. Participants were required to complete a consent form before beginning the experiment. The experiment began with an information screen pertaining instructions for the task, (Figure 3.1).

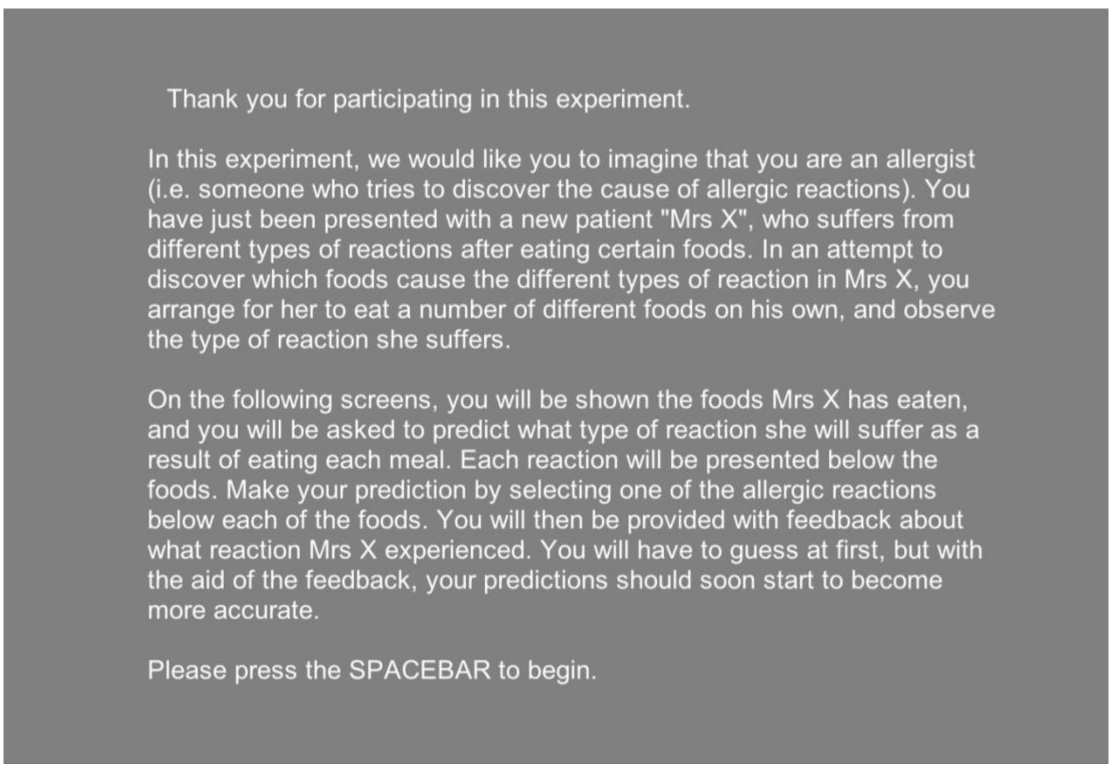


Figure 3.1: Information screen for Study 1

On each Stage 1 trial, participants were presented with food items on screen with no time limit, either alone (blocking trials - E, F, G, H) or in pairs (learned predictiveness trials - AX, AY, BX, BY, CW, CZ, DW, DZ) and were required to choose 1 out of 4 possible allergy outcomes (refer to Figure 3.2). Participants received immediate feedback (6 cm (width) x 2.5 cm (width) based on their answers (Figure 3.3), for 4 seconds before proceeding to the next trial.

a) b)

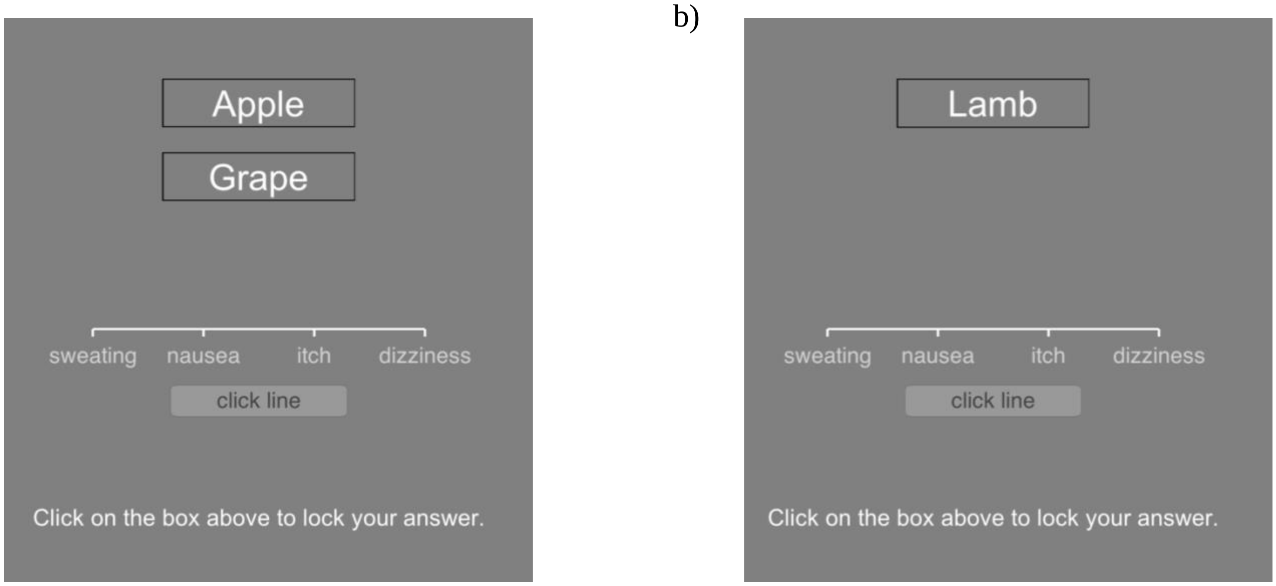


Figure 3.2: Example of a) learned predictiveness trial, b) blocking trial in Stage 1

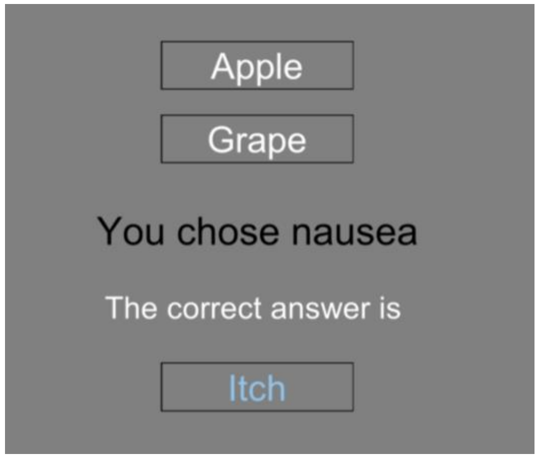


Figure 3.3: Feedback screen

Stage 1 comprised 12 blocks of training trials. Within each block, there were 4 blocking trials (E, F, G and H) and 8 learned predictiveness trials (AX, AY, BX, BY, CW, CZ, DW, DZ). Within each block, the trial order was randomised, and each block was presented 12 times to make a total of 144 trials (96 learned predictiveness trials; 48 blocking trials). For each learned predictiveness trial type, the order of presentation of the foods on the screen (top/bottom) was counterbalanced. The allergy outcomes for the learned predictiveness trials were always Allergy 1 and 2 (AX, AY, CW, CZ = O1; BX, BY, DW, DZ = O2) whereas the allergy outcomes for the blocking trials were always Allergy 3 and 4 (E and F = O3; G and H = O4), see Table 3.1. The identities of the outcomes were not counterbalanced.

Stage 2 followed seamlessly after Stage 1 and comprised 6 blocks of training. Within each of the 6 blocks there were 4 blocking trials (EP/FQ/GR/HS) and 4 Learned Predictiveness trials (AW/BZ/CX/DW) to make a total of 48 trials (24 learned predictiveness trials; 24 blocking trials. Within each block, the order of the trial type presentation was randomised. The format of the presentation of food items and allergy was exactly the same as in Stage 1. Immediate feedback was also given.

For the learned predictiveness trials, the food compounds from Stage 1 were shuffled to create never before seen compounds for Stage 2 in order to produce a novel learning context. For the blocking trials, new food items are introduced to previously seen foods to create food compounds, see Table 3.1.

At the end of Stage 2, participants were given a new set of instructions where they were asked to rate the individual food items, see Figure 3.4). 12 food items (A, B, C, D, W, X, Y, Z = learned predictiveness; P, Q, R, S, = blocking) were presented in a random order for rating. Participants were required to place their rating for both Allergy 3 and 4 on a 11-point Likert scale (refer to Figure 3.5). They then pressed the spacebar to move onto the next trial. Participants could not move to the next trial until they had provided a rating for the current food for each of the two allergies.

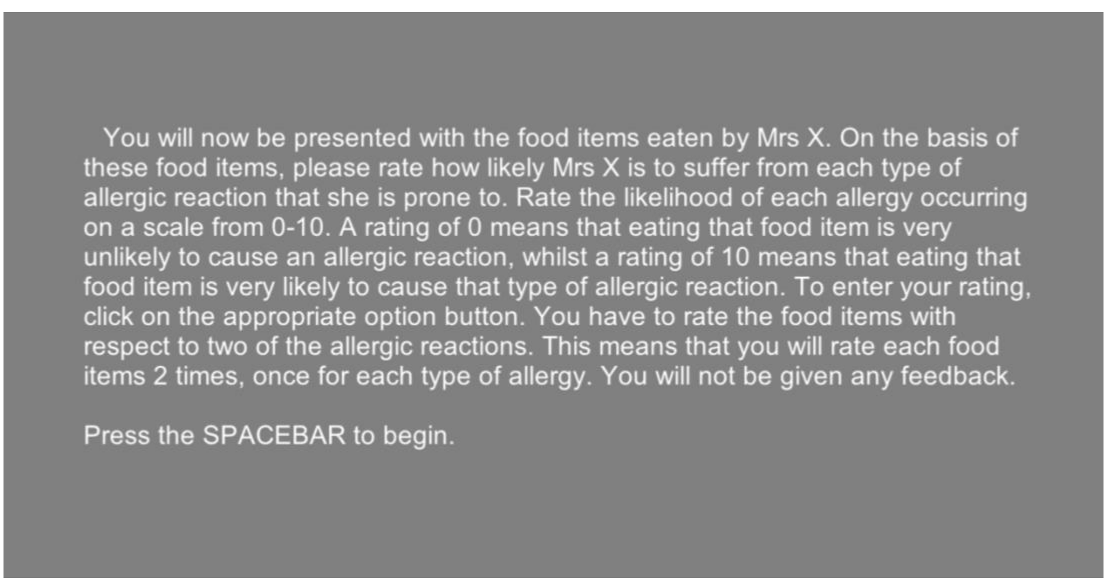


Figure 3.4: Instructions for the test stage

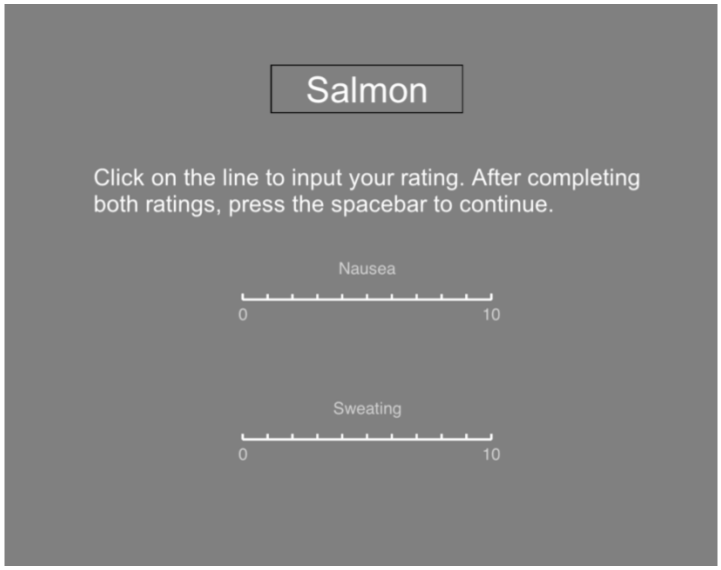


Figure 3.5: Rating screen

3.1.iii: Results

3.1.iii.a: Data treatment

10 participants were excluded from the final analysis because they did not achieve the 60% or more accuracy criteria for all trials in Stage 1, the same criterion used in Le Pelley and McLaren (2003).

Responses from the training stages (Stage 1 and 2) were coded as ‘1’ if participants correctly predicted the food-allergy association within the trial and ‘0’ if they did not. These responses are then arranged according to their trial presentation. For example, trial 1, trial 2...trial 12 in Stage 1; and trial 1, trial 2...trial 6 in Stage 2. An average for each trial block was calculated to obtain the mean proportion of correct responses from participants for each trial type.

A difference score was calculated for the learned predictiveness and blocking test ratings. Here the stimulus-outcome rating for the outcome which the stimulus *was not* paired with in Stage 2 were subtracted from the ratings for the outcome, which was paired with in Stage 2. For example, if the correct outcome for the stimulus was Outcome 3 in Stage 2, then the equation would be ratings for Outcome 3 – ratings for Outcome 4; and if the correct outcome was Outcome 4, it would be Outcome 4 - Outcome 3, see Equation 4.

The ratings for each relevant stimulus (A/B/C/D) were then averaged to provide an overall “relevant” score and the same for the irrelevant stimuli (W/X/Y/Z) to provide an overall “irrelevant” score. The same procedure was conducted for the blocking task. The scores for the blocked stimuli (P/S) were averaged to provide an “blocked” score and the control stimuli (Q/R) were averaged to provide a “control” score.

As the design of this study is novel, Bayesian paired samples t-test were used to determine whether a learned predictiveness and blocking effect can be found. Dienes (2014) states that a Bayes Factor of < 0.33 is in support of the null hypothesis, a Bayes Factor of > 3 is support of the alternative hypothesis and a Bayes Factor of > 0.33 but < 3 is evidence of a weak or anecdotal effect and requires further data collection.

3.1.iii.b: Analysis

Figure 3.6a shows that as training in stage 1 progressed, the mean proportion of correct trials increased for both the learned predictiveness and blocking trials, and that learning was more successful to the blocking than the learned predictiveness trials. This was confirmed by a 2 (stimuli) x 12 (trials) repeated measures ANOVA. There was a main effect of stimuli, $F(1, 31) = 22.00$, $p < 0.001$, $\eta_p^2 = 0.42$; and a main effect of trials, $F(11, 341) = 84.56$, $p < 0.001$, $\eta_p^2 = 0.73$, but no interaction between these variables, F(6.91, 214.27[3]) = 1.27, $p = 0.27$, $\eta_p^2 = 0.04$. One sample t-tests revealed that performance in both stimuli on trial 12 was significantly above chance (50%) smallest $t(31) = 13.93$, $p < 0.001$, $d = 2.46$. This means that participants successfully learned the discriminations for both learned predictiveness and blocking trials in Stage 1.

Footnote 3: If Mauchly's sphericity was violated, the Greenhouse-Geiser correction will be used. This will be repeated throughout the thesis.

Figure 3.6b shows that for the learned predictiveness trials in Stage 2, because of the change in contingencies, participants' accuracies started off below chance but gradually became more accurate as they experienced more trials, suggesting that participants adapted appropriately to the new food compounds and outcomes. With regards to blocking trials, participants' accuracies for the control stimuli were around chance presumably due to addition of new stimuli being compounded with previously seen stimuli and associations with new outcomes, but their accuracies improved with the subsequent trials. For the blocked stimuli trials, even with the addition of a new stimuli to form a compound, as the outcome associations remained the same, participant's accuracies were relatively high throughout the trials. This was confirmed with a 3 (stimuli) x 6 (trials) repeated measures ANOVA was conducted and there was a main effect of stimuli, $F(2, 62) = 44.38$, $p < 0.001$, $\eta_p^2 = 0.59$; and a main effect of trials, $F(3.69, 114.52) = 36.18$, $p < 0.001$, $\eta_p^2 = 0.54$. There was also an interaction between stimuli and trials, $F(10, 310) = 8.69$, $p < 0.001$, $\eta_p^2 = 0.22$. Post-hoc analyses revealed a significant main effect of trial for all types of trials, largest $F(3.38, 104.75) = 34.37$, $p < 0.001$, $\eta_p^2 = 0.53$, indicating an improvement in accuracy in all of the stimuli. One sample t-tests revealed that performance in all stimuli on trial 6 was significantly above chance (50%) smallest $t(31) = 5.31$, $p < 0.001$, $d = 0.94$.

Figure 3.7 shows the mean ratings provided by participants in the test stage, where ratings for the blocked stimuli was the highest, followed by relevant stimuli, the control stimuli and the irrelevant stimuli. A one-way repeated measures ANOVA revealed there was a difference in mean difference ratings for the four different stimuli types, $F(3, 93) = 3.41$, $p = 0.02$, $\eta_p^2 = 0.10$, suggesting a difference in rating between the stimuli. Participants provided higher ratings for the relevant stimuli ($M = 2.05$, $SEM = 0.47$) than the irrelevant stimuli ($M = 0.38$, $SEM = 0.52$) and this was confirmed with a Bayesian paired samples t-test, $t(31) = 2.30$, $p = 0.01$, $BF_{10} = 3.62$, $d =$

0.41, supporting a learned predictiveness effect. Surprisingly, participants provided numerically higher ratings for the blocked stimuli (*M* = 2.86, *SEM* = 0.77) than the control stimuli (*M* = 1.72, *SEM* = 0.64), however, a Bayesian paired samples t-test revealed no significant difference between these stimuli, $t(31) = -1.22$, $p = 0.89$, $BF_{10} = 0.09$, $d = -0.22$.

a) b)

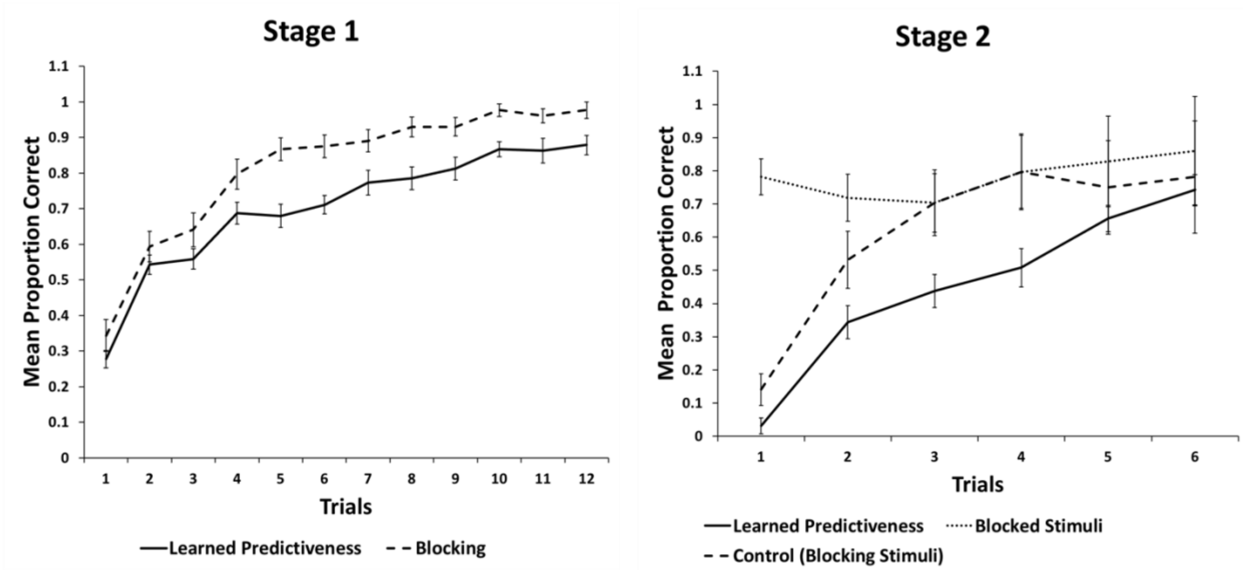


Figure 3.6: Mean proportion correct across trials in Stage 1 and 2 in Study 1. Error bars represent standard error of mean.

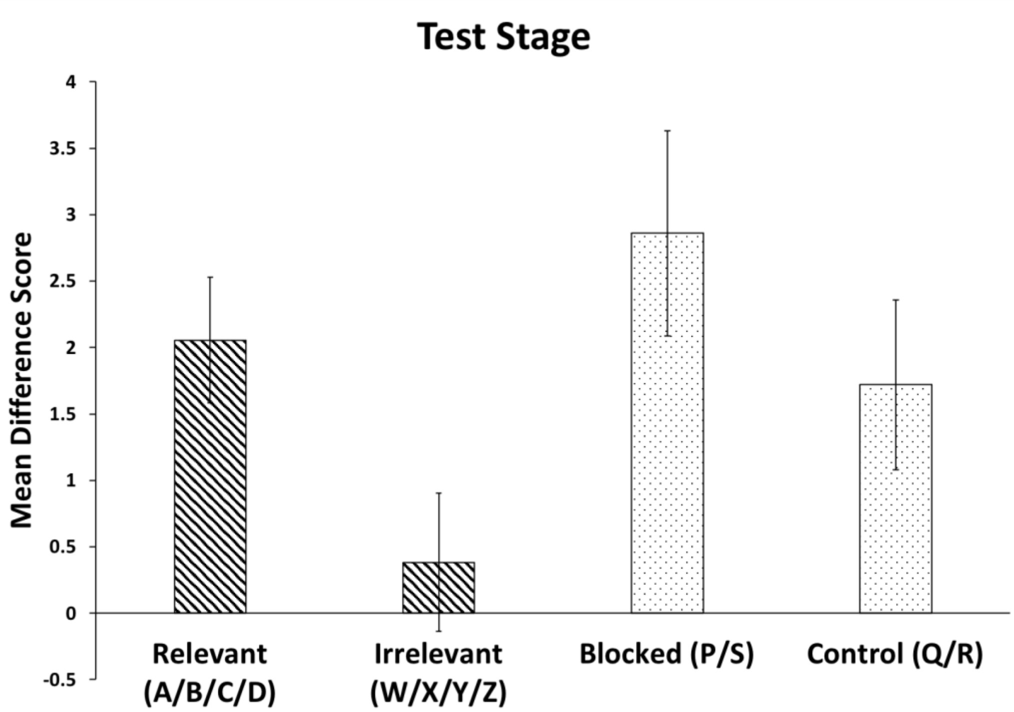


Figure 3.7: Mean difference ratings to the stimuli during the test stage of Study 1. Error bars represent standard error of mean.

3.1.iv: Discussion

The aim of Study 1 was to determine if both the effects of blocking and learned predictiveness could be found using the same procedure in a within-subjects design. To summarise the results, participants were tested with a food allergist task that was embedded with a learned predictiveness and blocking design. Results from Stage 1 demonstrated that participants successfully learned the A/C → Outcome 1 and B/D → Outcome 2 associations, and because stimuli W/X/Y/Z predict Outcome 1 and 2 equally, there should be no discrimination between them. In Stage 2, when provided with new compounds and outcomes, participants also successfully learned the new associations. In the test stage, participants provided higher ratings for the relevant (A/B/C/D) stimuli as compared to the irrelevant (W/X/Y/Z) stimuli, indicating a learning bias from Stage 1 to Stage 2 consistent with the Mackintosh theory where stimuli with a history of being a good predictor will be learned about more than stimuli with a history of being a bad predictor. These findings show that learned predictiveness effect described in Le Pelley and McLaren (2003) was successfully replicated.

In relation to the blocking trials, the results show that participants successfully learned the E/F → Outcome 3 and G/H → Outcome 4 associations in Stage 1. In Stage 2, when E/H was compounded with a new stimulus respectively and paired with the same outcome as in Stage 1, learning start above chance and remained throughout all the trials. In the case of F/G, when they were compounded with a new stimulus respectively but the outcome it was paired with initially was switched, learning started below chance but eventually improved across the trials suggesting that participants successfully learned the new associations. Interestingly, the ratings for the blocked stimuli were, if anything, higher than the control stimuli, and therefore, show no blocking effect. According to the Rescorla-Wagner model, when E and H were paired with Outcome 3 and

4 respectively in Stage 1, and when E and H were compounded with P and S in Stage 2 respectively, very little learning about the P → Outcome 3 and S → Outcome 4 should occur. This is because when P and S were introduced for conditioning, the increment for each of their associative strengths will be determined by the discrepancy between λ and $\Sigma V_{EP}/\Sigma V_{HS}$. Prior conditioning of E and H will mean that this discrepancy is close to 0 and hence, P and S will gain little associative strength. The findings of this study however, revealed that ratings for P and S are comparable to Q/R, which was inconsistent with prior predictions.

This study is, to the best of our knowledge, the first in which blocking and learned predictiveness have been studied in the same task. It is therefore possible that, for whatever reason, the presence of the learned predictiveness trials interrupted or in some way masked the blocking effect. Therefore, a further study where the learned predictiveness procedure will be removed to determine if the blocking effect could then be found.

3.2: Study 2: Replication of blocking design

3.2.i: Introduction

The findings obtained from Study 1 demonstrated a learned predictiveness effect but not a blocking effect. This is interesting as the Le Pelley (2004) hybrid model (see Chapter 1.11), for example, would predict blocking to be a more robust effect than learned predictiveness. This model is made up of three components, the summed error term from the Rescorla-Wagner (1972) model, the α component from the Mackintosh (1975a) theory and the σ from the Pearce-Hall (1980) model; and all three can explain blocking but learned predictiveness can only be predicted by the Mackintosh theory.

Referring back to the blocking design in Study 1, the Rescorla-Wagner model predicts that when E was repeatedly associated with Outcome 3, the prediction error will decrease, and learning will reach asymptote. Subsequently in Stage 2, when a new stimulus (P) was compounded (EP), previous learning of the E → Outcome 3 association limited or "blocked" the learning of the P → Outcome 3 association causing P to gain little associative strength. According to both the Mackintosh theory and Pearce-Hall model, on the first compound trial, attention towards E and P was relatively high due to the novelty of the added stimulus and can therefore acquire some associative strength. After this, the two models make two different accounts on why blocking occurs. The Mackintosh theory predicts that during the first compound trial, participants learned that P was a relatively worse predictor of Outcome 3 as opposed to E and therefore, its associability dropped, and no further learning occurred. Meanwhile, the Pearce-Hall model predicts that on the first compound trial, participants learned that P was followed by an outcome that was not surprising as E was already paired with Outcome 3. Therefore, P was ignored on any further trial and gained little associative strength.

This being said, learned predictiveness can only be explained by the Mackintosh component of the hybrid model, which predicts that participants would pay more attention towards previously relevant predictors relative to the previously irrelevant predictors. A similar prediction can be derived from other Hybrid models (e.g., Pearce and Mackintosh, 2010; Esber and Haselgrove, 2011).

This then brings the question of whether the reason why blocking was not observed was because of a disruption from the learned predictiveness effect. It is possible that the rules used from the learned predictiveness procedure (i.e., since E was consistently predicting Outcome 3, then it must be a good predictor) could have carried over to the blocking procedure, which would explain why participants provide higher ratings towards the stimuli that was compounded with the "good predictor" compared to the stimuli that was compounded with the "bad predictor". Therefore, the aim of this study was to remove the learned predictiveness procedure to determine if the proposed blocking procedure can generate the effects of blocking. This study thus predicts that ratings for the blocked stimuli to be lower than the control stimuli.

3.2.ii: Methods

3.2.ii.a: Design

This design of this study is the same as Study 1 with the exception that it only consisted of the blocking trials, see Table 3.1. Also, instead of 4 outcomes presented, participants only saw 2 possible outcomes they could respond to (i.e., Outcome 3 and 4).

3.2.ii.b: Participants

32 (Male = 10, Female = 22) University of Nottingham students participated in this study. The age of the participants ranged from 18 to 29 years old, (M = 20.72, SD = 3.07). Participants were recruited through the school's Research Participation Scheme, social media platform (Facebook), recruitment posters and word of mouth. Participants had either normal or corrected vision.

3.2.iii: Results

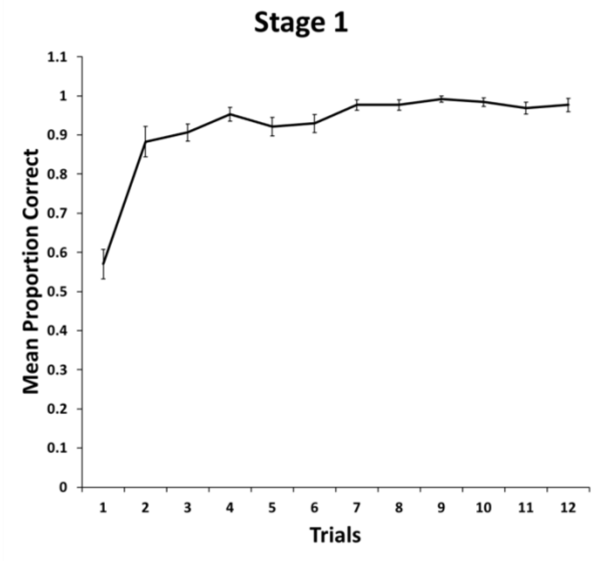
3.2.iii.a: Analysis

No participants were omitted as they all achieved 60% accuracy in Stage 1. Figure 3.8a shows that in Stage 1, as participants experienced more trials, their accuracies increased and this was confirmed with a one-way repeated measures ANOVA where there was a significant difference, $F(4.46, 138.23) = 34.18$, $p < 0.001$, $\eta_p^2 = 0.52$, indicating that performance improved as training progressed. A one sample t-test was conducted (test value = 0.5) on trial 12 to determine if responding was above chance (0.50); there was a significant difference, $t(31) = 27.64$, $p < 0.001$, $d = 4.89$. This indicates that participants successfully learned the associations between stimuli and outcomes.

Figure 3.8b shows that in Stage 2, participants' accuracies for the control trials were below chance as the contingencies between cue and outcome had changed between Stage 1 and Stage 2, but their accuracies improved with the subsequent trials. However, the blocked stimuli trials accuracies started relatively high, which remained throughout the trials. This was confirmed with a 2 (stimuli) x 6 (trials) repeated measures ANOVA which revealed a main effect of stimuli, $F(1, 31) = 12.41$, $p = 0.001$, $\eta_p^2 = 0.29$; and a main effect of trials, $F(3.39, 105.14) = 34.19$, $p < 0.001$, $\eta_p^2 = 0.52$. There was also an interaction between stimuli and trials, $F(3.09, 95.85) = 23.83$, $p < 0.001$, $\eta_p^2 = 0.44$. Post-hoc analyses revealed a significant main effect of trial for control trials, $F(5, 155) = 53.85$, $p < 0.001$, $\eta_p^2 = 0.64$, and there was no significant difference for the blocked stimuli, $F(3.24, 100.43) = 1.53$, $p = 0.18$, $\eta_p^2 = 0.05$. One sample t-tests revealed that performance in both stimuli on trial 6 was significantly above chance (50%) smallest $t(31) = 8.35$, $p < 0.001$, $d = 1.52$, suggesting that participants successfully learned the new associations.

Figure 3.9 shows ratings for the blocked stimuli were numerically higher ($M = 5.16$, $SEM = 0.65$) than the control ($M = 4.50$, $SEM = 0.77$) stimuli. A Bayesian paired samples t-test was conducted and there was no significant difference, $t(31) = -1.20$, $p = 0.88$, $BF_{10} = 0.09$, $d = -0.21$, supporting no blocking effect.

a)



b)

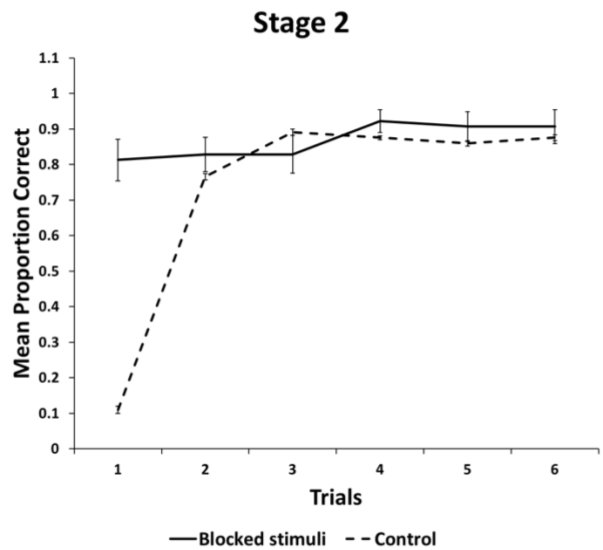


Figure 3.8: Mean proportion correct across trials in Stage 1 and 2 in Study 2. Error bars represent standard error of mean.

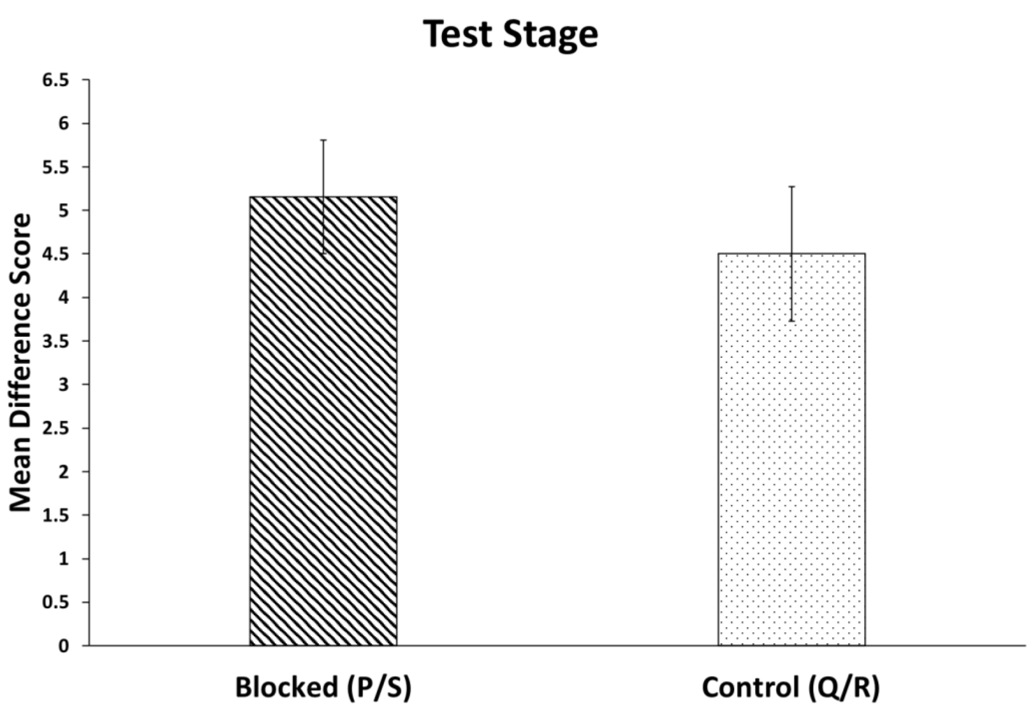


Figure 3.9: Mean difference ratings to the stimuli during the test stage of Study 2. Error bars represent standard error of mean.

3.2.iv: Discussion

Study 2 was conducted to determine if the absence of a blocking effect in Study 1 was due to the potential interference from the learned predictiveness procedure. Thus, only the blocking design was tested. Participants showed successful learning of the relationship between the stimuli and outcomes in Stage 1. In Stage 2, participants also successfully learned the associations between the stimuli and outcome in the control conditions, learning about the blocking stimuli transferred from Stage 1 to the compounds in Stage 2. In the test stage, the mean ratings for the blocked stimuli were marginally higher than control stimuli, replicating the findings of Study 1, thus indicating no blocking effect. This result suggests that the learned predictiveness design did not interfere with blocking.

During Pavlovian conditioning using compound CS, associations between individual stimulus of the compound may form (Rescorla and Durlach, 1981). Hence, a potential reason for why blocking cannot be found is perhaps in Stage 2, X formed an association with the blocking stimuli A rather than, or in addition to, the target outcome causing a within-compound association to develop. When subsequently tested, the indirect association of X → A will influence the X's associative strength and may therefore have caused participants to rate X higher than Y. Therefore, the next experiment reported will determine if this is the case.

3.3: Study 3: Blocking and Within-compound association

3.3.i: Introduction

It was predicted that the learned predictiveness procedure was disrupting the effects of the blocking procedure in Study 1. However, the results from Study 2 shows that this was not the case – blocking was not observed even when the learned predictiveness trials employed in Experiment 1 were omitted. It is therefore appropriate to consider what other factors might have been precluding the observation of blocking, and one possibility is the presence of a within-compound association.

In a standard blocking task in which stimuli A and X are presented together and followed by an outcome, it is typically assumed that conditioned responding to X is determined by the strength of the association between X and the outcome. However, this analysis ignores the possibility that during AX-Outcome trials, an association might also be acquired between X and A. If this is the case, then any associative strength that A has (e.g., the association acquired with the outcome in Stage 1) will influence responding to X. For example, at the test stage, presentation of X may activate a representation of A (through the X-A association acquired in Stage 2), which in turn will activate a representation of the outcome (through the A-Outcome association acquired in Stage 1). Under these circumstances, then, whilst X may have little direct associative strength for the Outcome, it may, nonetheless, be able to evoke responding through the indirect X →A → Outcome chain of associations.

Therefore, this study aimed to determine if the failure to find blocking is due to within-compound associations that were acquired in Stage 2. A standard way in which to identify the presence of within compound associations is to first present two cues (e.g., E and P) together to provide the opportunity for a putative within-compound association to form between them. Then, to detect the presence of the within compound association, the value of one of the stimuli (e.g., E) is changed by, for example pairing it with a US, and the associate of this stimulus (E) is tested alone. If a within compound association formed between E and P in the initial stage of this experiment then changing the value of one stimulus will have an impact upon responding to the other, relative to an appropriate control (e.g., Rescorla & Cunningham, 1978).

The current study employed the same logic. We first replicate the two training stages and the test from Study 2, to set up the circumstances for a within compound association to form in Stage 2 of the blocking procedure (see Table 3.2) but then adding a Stage 3, in which trials with E, F, G and H are included. The outcomes following trials with E and F will be reversed, relative to Stage 1 to change their value and (if there is a within compound association) change responding to their associates, whilst the trials with G and H will be consistent (refer to Table 3.2). Based on Study 1 and 2, it was predicted that during Test Stage 1, no blocking effect will be found, where usually it would be expected that ratings for the blocked stimuli (P/Q) will be lower than the control stimuli (R/S). If responding to the blocked stimuli (P and Q) is based upon within compound associations to E and F (and hence O1 and O2 respectively) then reversing the reversal training in Stage 2 should have an impact upon the ratings of these stimuli relative to the control stimuli, as described above.

3.3.ii: Methods

3.3.ii.a: Design

Table 3.2: Study 3 design table. Letters E to S represent the different food items (stimuli)

Stage 1	Stage 2	Test	Stage 3	Test 2
E - O3	EP - O3	P	E - O3	P
F - O4	FQ - O4	Q	F - O4	Q
G - O3	GR - O4	R	G - O4	R
H - O4	HS - O3	S	H - 03	S

3.3.ii.b: Participants

32 (Male = 12, Female = 20) University of Nottingham students participated in this study. The age of the participants ranged from 18 to 38 years old, (M = 22.55, SD = 3.82). Participants were recruited through the school's Research Participation Scheme, social media platform (Facebook), recruitment posters and word of mouth. Participants had either normal or corrected vision.

3.3.ii.c: Procedure

The design and procedure from Stage 1 until test stage 1 was identical to Study 2. Following test 1, Stage 3 began, which comprised 12 blocks of trials, each of which included 4 types of trials (E-O2, F-O1, G-O1 and H-O2). There was a total of 48 trials and the order of trials was randomized within each block. Each trial was self-paced. At the end of Stage 3, participants were once again asked to provide ratings to the foods as in test stage 1.

3.3.iii: Results

3.3.iii.a: Analysis

Figure 3.10a shows that in Stage 1, as participants experienced more trials, their responses increased in accuracy, and this was confirmed with a one-way repeated measures ANOVA where there was a significant difference, $F(4.42, 136.99) = 28.16$, $p < 0.001$, $\eta_p^2 = 0.48$. A one sample t-test was conducted (test value = 0.5) on trial 12 to determine if responding was above chance (50%); there was a significant difference, $t(31) = 31.57$, $p < 0.001$, $d = 5.58$.

Figure 3.10b shows that in Stage 2, for the blocked trials, participants' responses were above chance, while the control trials were below chance at the beginning with accuracies rapidly increasing across the six trial blocks. This was confirmed with a 2 (stimuli) x 6 (trials) repeated measures ANOVA was conducted and there was a main effect of stimuli, $F(1, 31) = 16.83$, $p < 0.001$, $\eta_p^2 = 0.35$; and a main effect of trials, $F(3.39, 105.07) = 41.09$, $p < 0.001$, $\eta_p^2 = 0.57$. There was also an interaction effect of stimuli and trials, $F(3.79, 117.42) = 23.98$, $p < 0.001$, $\eta_p^2 = 0.44$. Post-hoc analyses revealed a significant main effect of trial for both types of trials, largest $F(3.89, 120.44) = 74.63$, $p < 0.001$, $\eta_p^2 = 0.71$, indicating an improvement in accuracy in all of the stimuli. Further analysis using a simple main effect analysis indicated that the blocked stimuli trials were significantly higher than the control stimuli trials only on trial 1(p < 0.001). One sample t-tests revealed that performance in both stimuli on trial 6 was significantly above chance (50%) smallest $t(31) = 10.66$, $p < 0.001$, $d = 1.88$.

Figure 3.11a shows that, at test 1, participants provided numerically higher ratings to the blocked stimuli and lower ratings to control stimuli ($M = -3.03$, $SEM = 0.91$). A Bayesian paired samples t-test was conducted and there was a significant difference, $t(31) = -4.79$, $p < 0.001$, BF_{10}

= 0.04, *d* = -0.85. However, the Bayes factor is supporting the null hypothesis, which was that no blocking effect was observed.

Figure 3.10c shows that participants were responding above chance for the control trials, G and H while participants were responding below chance for the switched trials, E and F, which is consistent with the fact that its contingencies remained the same from Stage 1 to 2 but changed in Stage 3. This was confirmed with a 2 (stimuli) x 12(trials) repeated measures ANOVA was conducted and there was a main effect of stimuli that was approaching significance, $F(1, 31) = 3.97$, $p = 0.06$, $\eta_p^2 = 0.11$; and a main effect of trials, $F(6.24, 193.56) = 20.85$, $p < 0.001$, $\eta_p^2 = 0.40$. There was also an interaction effect of stimuli and trials, $F(6.13, 190.00) = 6.86$, $p < 0.001$, $\eta_p^2 = 0.18$. Post-hoc analyses revealed a significant main effect of trial for both types of trials, largest $F(6.05, 187.48) = 22.49$, $p < 0.001$, $\eta_p^2 = 0.42$, indicating an improvement in accuracy in all of the stimuli. One sample t-tests revealed that performance in both stimuli on trial 6 was significantly above chance (50%) smallest $t(31) = 11.59$, $p < 0.001$, $d = 2.05$.

Figure 3.11b shows the difference ratings for test 2. Participants provided numerically higher ratings for P/Q ($M = 0.81$, $SEM = 0.92$) and lower ratings to R/S ($M = -0.53$, $SEM = 0.83$) stimuli. A Bayesian paired samples t-test, however, found no significant difference, $t(31) = -1.06$, $p = 0.85$, $BF_{10} = 0.10$, $d = -0.19$.

A 2 (stimuli) x 2(test stages) repeated measures ANOVA was conducted and there was a main effect of stimuli, $F(1, 31) = 12.49$, $p = 0.001$, $\eta_p^2 = 0.29$; and no main effect of test stages, $F(1, 31) = 0.001$, $p = 0.97$, $\eta_p^2 < 0.001$. There was also an interaction effect of stimuli and test stages, $F(1, 31) = 12.22$, $p = 0.001$, $\eta_p^2 = 0.28$ and post-hoc Bayesian paired samples t-tests were conducted to compare the ratings for the stimuli between the test stages; switched stimuli, $t(31) = 2.27$, $p = 0.02$, $BF_{10} = 3.43$, $d = 0.40$ and control stimuli, $t(31) = 2.72$, $p = 0.01$, $BF_{10} = 4.15$, d = -

0.48. If only the associates of the switched stimuli (P and Q) showed a significant reduction in ratings, then we could have more confidence in the conclusion of there being a within-compound association between these stimuli and E and F. However, there was also significant reduction in the ratings to the stimuli that were associates of the non-switched stimuli (R and S). It is therefore difficult to conclusively determine that a within-compound association was observed. Instead, it could be the case that participants simply forgot which outcomes were associated with which stimuli between test 1 and test 2.

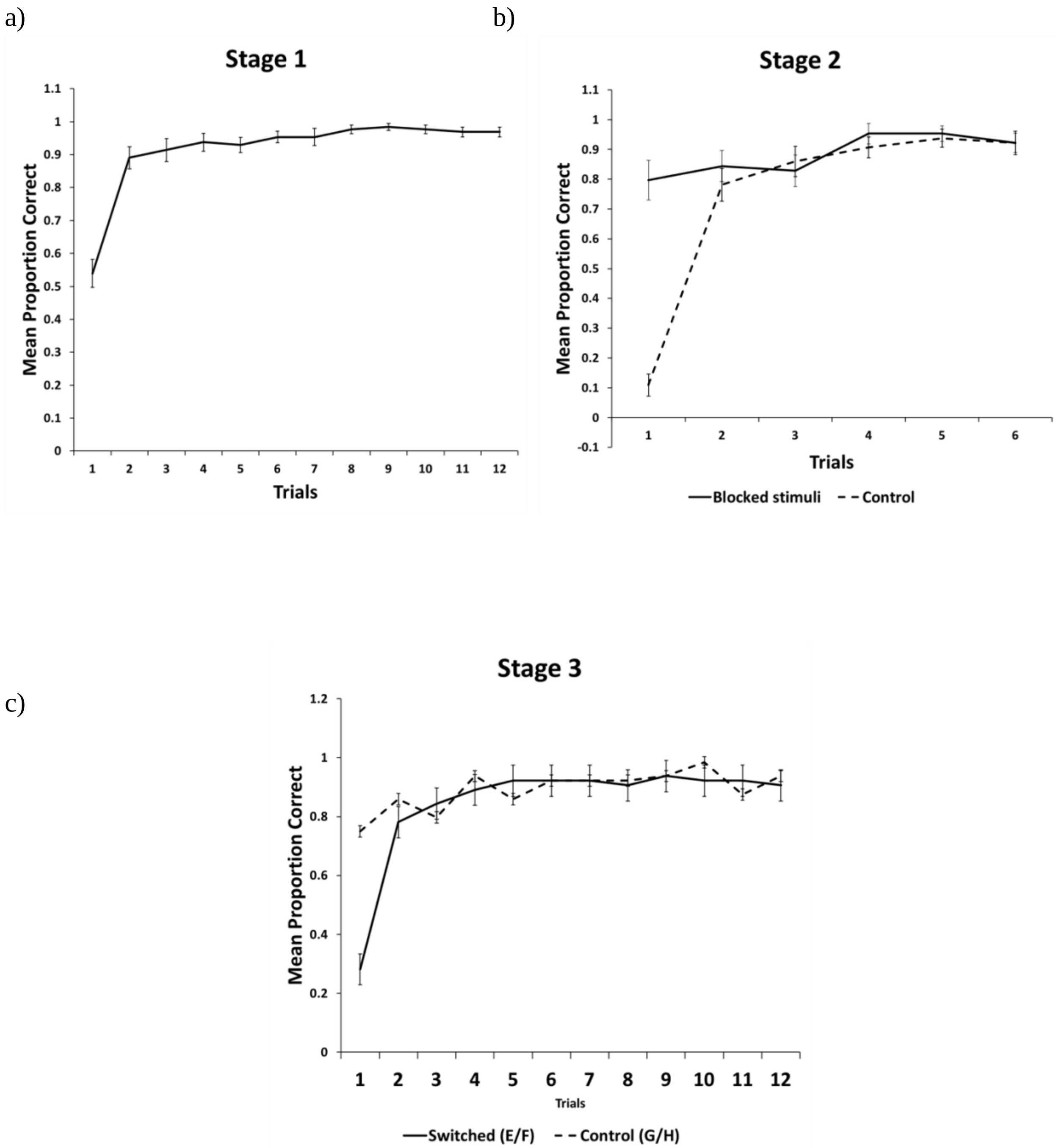
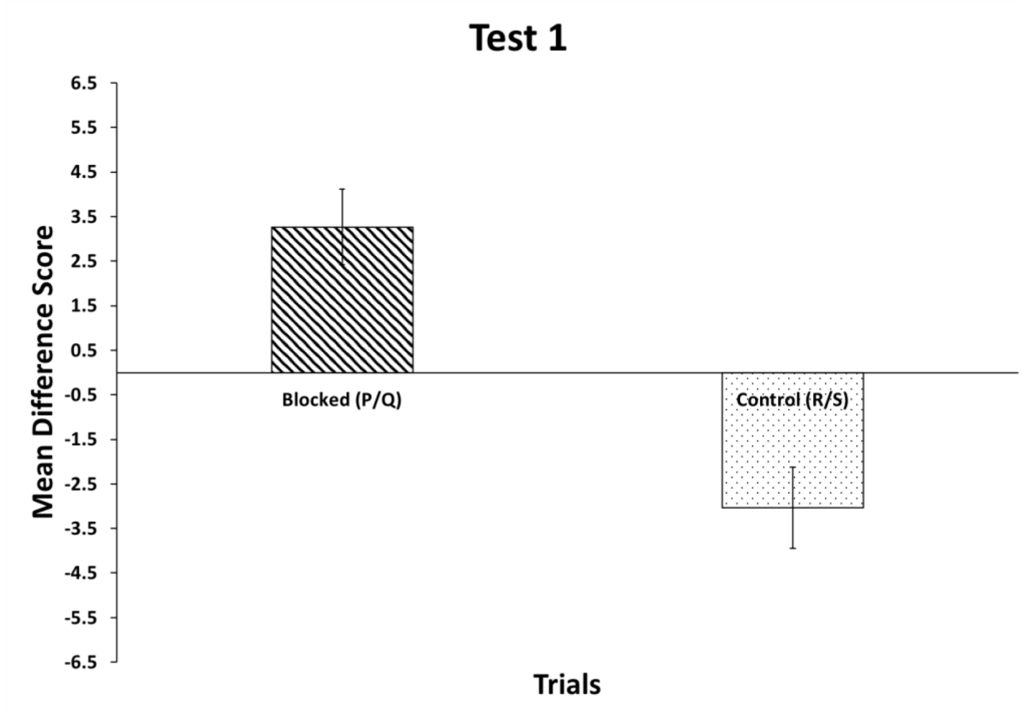


Figure 3.10: Mean proportion correct across trials in Stage 1, 2 and 3 in Study 3. Error bars represent standard error of mean.

a)



b)

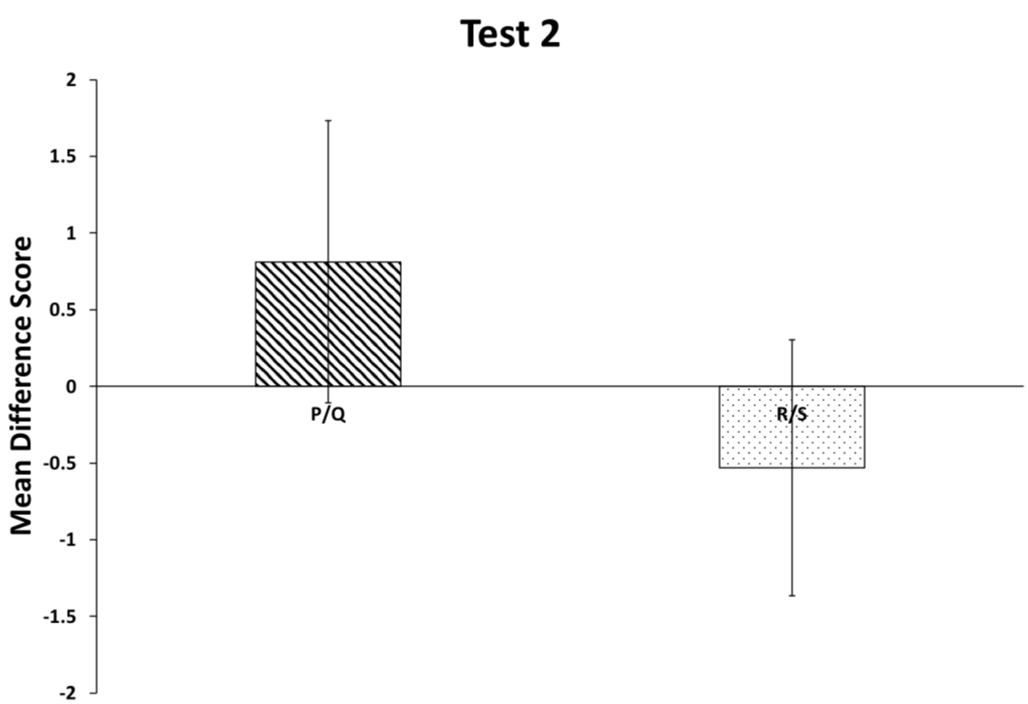


Figure 3.11: Mean difference ratings to the stimuli during the test stage of 1 and 2 in Study 3. Error bars represent standard error of mean.

3.3.iv: Discussion

Study 3 was conducted to investigate if the inability to reproduce blocking is because an association has been formed between the to-be-blocked and blocking stimuli instead of, or in addition to, the to-be-blocked stimuli with the target outcome. Participants showed successful learning of the associations between stimuli and outcome in Stage 1 and 2. In the first test stage, mean ratings for the blocked stimuli was once again higher than the control stimuli, showing no blocking effect, and if anything revealed an augmentation effect. In Stage 3, the outcomes for E/F were switched and participants successfully learned the new associations. If a within-compound association was made between the to-be-blocked and blocking stimuli (EP/FQ), mean ratings for these stimuli will be lower than ratings made in the first test stage and there will not be a difference in the control stimuli (GR/HS). However, the results show that the mean ratings for P/Q were numerically higher than R/S in both test stages 1 and 2.

A numerical reduction in ratings to P/Q at test 2 relative to test 1 suggests that there was a within-compound association effect occurring. However, a concurrent reduction of the control stimuli (R/S) suggests that perhaps the participants simply forgot the associations because of the additional training stage. Another potential reason why blocking could not be observed is because the design was not sensitive enough to generate an effect, and thus, the next study will report a food allergist task using the blocking design as in Kamin (1969).

3.4: Study 4: Kamin blocking

3.4.i: Introduction

Study 3 hypothesized that a within-compound association may have formed between the compounds in Stage 2, but results show no support of this. Study 1 to 3 all employed the same design. In particular a control condition in which the identity of the outcome is switched between Stage 1 and Stage 2. It is conceivable that this control condition in some way interfered with the expression of blocking (but see Haselgrove and Evans, 2010). Therefore, this study aimed to use the Kamin (1969) blocking design, which is less complicated as the control trials were removed from Stage 1, (see Table 3.3). This being the case, it would be predicted that ratings for the control stimuli will be higher than the blocked stimuli.

3.4.ii: Methods

3.4.ii.a: Design

Table 3.3: Study 4 design table. Letters A to Z represent the different food items (stimuli)

Stage 1	Stage 2	Test
A - O1	AW - O1	W
B - O2	BX - O2	X
	CY - O1	Y
	DZ - O2	Z

3.4.ii.b: Participants

31 (Male = 12, Female = 19) University of Nottingham students participated in this study. The age of the participants ranged from 18 to 27 years old, (M = 24.19, SD = 3.87). Participants were recruited through the school's Research Participation Scheme, social media platform (Facebook), recruitment posters and word of mouth. Participants had either normal or corrected vision.

3.4.ii.c: Procedure

Stage 1 consisted of 12 blocks of training trials with 2 blocking trials (A and B), making up 24 trials. In Stage 2, A and B were compounded with new food stimuli to create AW and BX. Additionally, two compounds containing novel food stimuli CY and DZ were presented to participants. Each of these compounds were repeated 6 times making a total of 24 trials. Within each trial block, the trial order was randomised. All other procedural details were the same as Experiment 2.

3.4.iii: Results

3.4.iii.a: Analysis

Figure 3.12a shows that in Stage 1, participants' response accuracies improved with each subsequent trial and this was confirmed with a one-way repeated measures ANOVA where there was a significant difference, $F(11, 330) = 13.43$, $p < 0.001$, $\eta_p^2 = 0.31$. All participants responded correctly on the last trial as they all showed 100% accuracy by the last trial so a one sample t-test cannot be carried out in Jamovi.

Figure 3.12b shows that in Stage 2, participants' responses to the blocked trials started off above chance and remained relatively accurate throughout all six trials while the blocked trials started around chance but gradually improved across the trials. This was confirmed with a 2 (stimuli) x 6 (trials) repeated measures ANOVA and there was an interaction between stimuli and trials, $F(3.11, 93.19) = 7.06$, $p < 0.001$, $\eta_p^2 = 0.19$. There was a main effect of stimuli, $F(1, 30) = 15.08$, $p = 0.001$, $\eta_p^2 = 0.34$, and a main effect of trials, $F(2.60, 77.96) = 9.15$, $p < 0.001$, $\eta_p^2 = 0.23$. Post-hoc analyses revealed a significant main effect of trial for both types of trials, largest $F(2.78, 83.24) = 10.22$, $p < 0.001$, $\eta_p^2 = 0.25$, indicating an improvement in accuracy in all of the stimuli. One sample t-tests revealed that performance in the control stimuli on trial 6 was significantly above chance (50%) smallest $t(30) = 12.69$, $p < 0.001$, $d = 2.28$.

In contrast to the results of Experiments 1 to 3, Figure 3.13 shows the ratings for the blocked stimuli were numerically lower ($M = 4.53$, $SEM = 0.75$) than the control stimuli ($M = 4.89$, $SEM = 0.85$). However, a Bayesian paired samples t-test was conducted and revealed no significant difference, $t(30) = 0.35$, $p = 0.37$, $BF_{10} = 0.26$, $d = 0.06$, suggesting no blocking effect.

a) b)

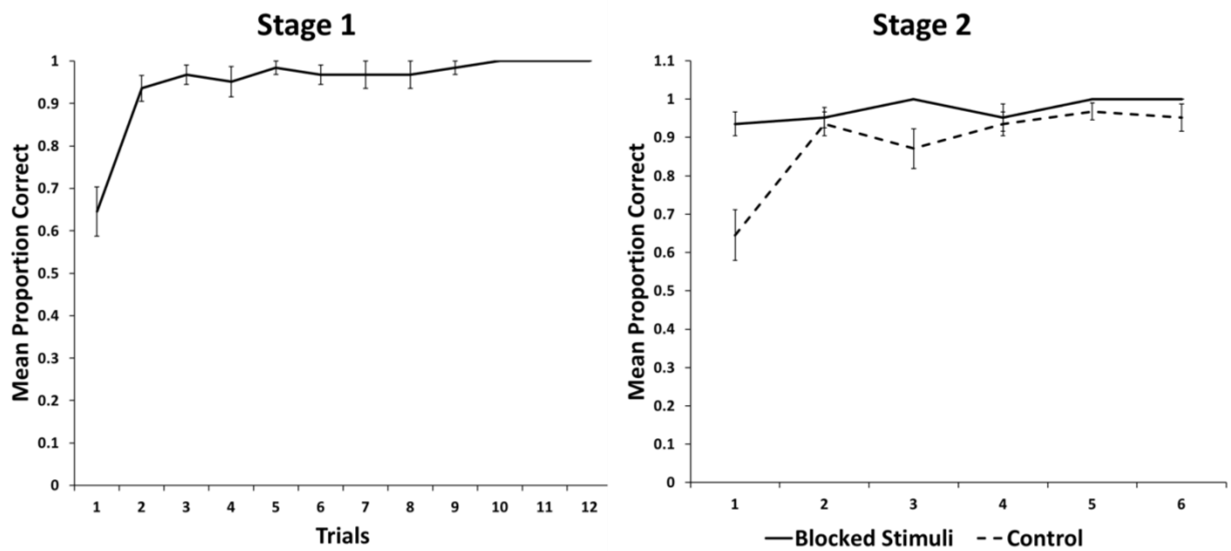


Figure 3.12: Mean proportion correct across trials in Stage 1 and 2 in Study 4. Error bars represent standard error of mean.

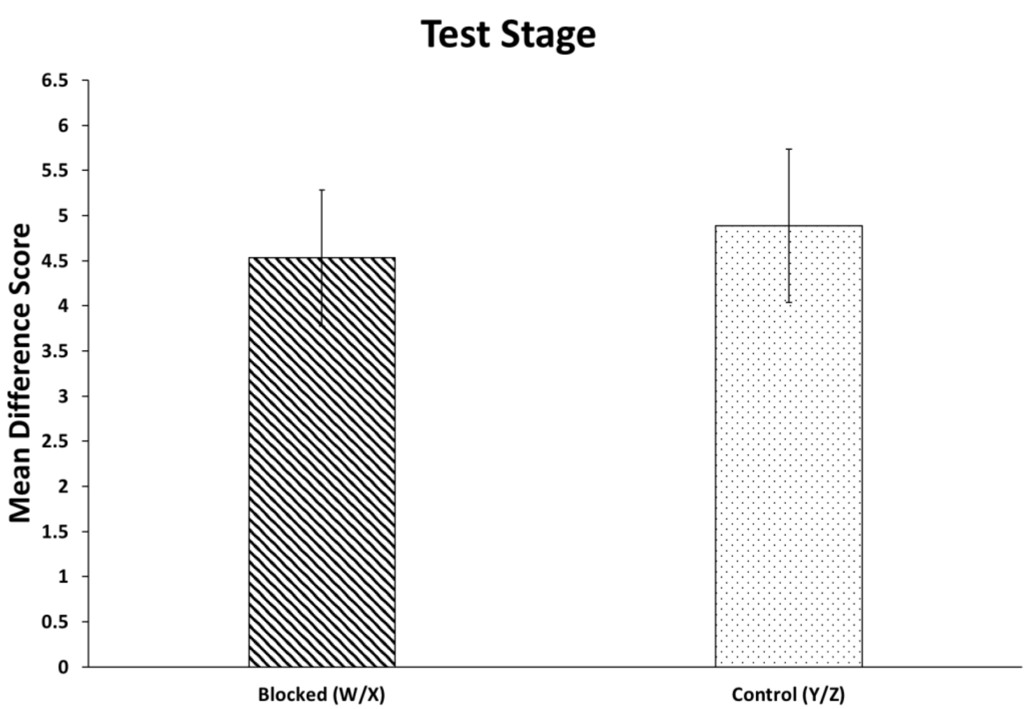


Figure 3.13: Mean difference ratings to the stimuli during the test stage of Study 4. Error bars represent standard error of mean.

3.4.iv: Discussion

Study 4 conducted a blocking study that employed a comparably simpler blocking design (Kamin, 1969) than previously used. Participants showed successful learning of associations between stimuli and outcome in Stage 1 and 2. In the test stage, mean ratings for the control stimuli was higher numerically than the blocked stimuli. The Bayesian analysis supports the null hypothesis, and hence, even though participants' ratings were in the right direction, no blocking effect can be reported. Further details on why blocking could not be observed will be discussed in the General Discussion to this chapter.

3.5: General Discussion

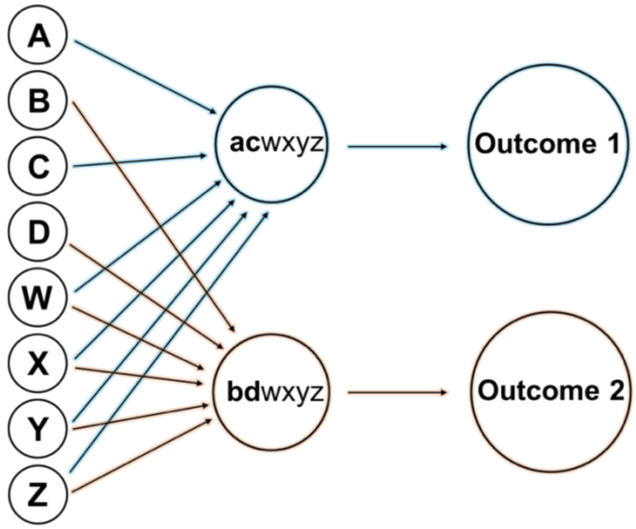
The aim for Study 1 was to determine if the effects of learned predictiveness and blocking could be obtained in the same individual. To achieve this, a food allergist task embedded with both procedures was employed. With regards to the learned predictiveness task, participants provided higher ratings to stimuli which had a history of being established as good predictors (relevant) and lower ratings to stimuli which were bad predictors (irrelevant), indicating more learning of relevant stimuli than irrelevant stimuli. However, the results of this study showed that participants provided higher ratings to the blocked stimulus rather than control stimulus, which is opposite of a blocking effect. This is in contrast with the predictions made by the hybrid model put forward by Le Pelley (2004), which incorporates Rescorla-Wagner's (1972) summed error term that governs the change in associative strength and two learning parameters, the α component which changes via the Mackintosh (1975a) theory rules and the σ component which changes via the Pearce-Hall (1980) model rules. According to Le Pelley (2004), blocking should be more robust as it is driven by the three components of the model (Rescorla-Wagner, Mackintosh and Pearce-Hall) while learned predictiveness can only be accounted for by the Mackintosh rule (See also Esber and Haselgrove, 2011; Pearce and Mackintosh, 2010).

There are two possible reasons as to why blocking was not observed in Studies 1-4. The first could be that participants simply failed to learn the associations between the stimuli and outcomes in Stage 1. However, if we look at acquisition data for all the studies, the results show that participants learned all the associations. If anything, there is better learning in the blocking trials as opposed to the learned predictiveness trials.

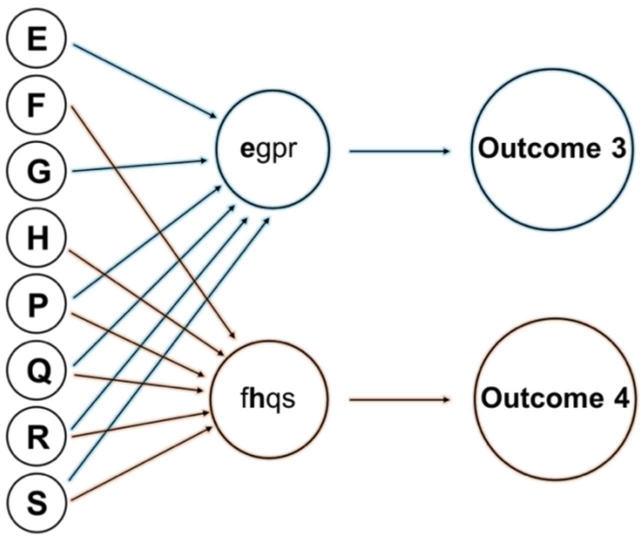
The other possibility was that Stage 1 learning did not generalise to Stage 2. However, when a one sample-test was conducted comparing the first trial in Stage 2 against chance, there was a significant differences in all of the Stage 2's trial 1s, smallest $t(30) = 2.19$, $p = 0.04$, $d = 0.37$.

However, these results can be explained using a theory introduced by Honey, Close and Lin (2010), which attempts to explain how stimuli acquire equivalence and distinctiveness as a result of training. Two stimuli can acquire equivalence when they are trained to elicit the same response as a result of conditioning (Miller and Dollard, 1941) and two stimuli can acquire distinctiveness as a result of discrimination training (Lawrence, 1949). According to this theory proposed by Honey et al, discriminability between stimuli increases when the stimuli predict different outcomes and discriminability decreases when the stimuli predict the same outcome.

a)


A
B
C
D
W
X
Y
Z
acwxyz
bdwxyz
Outcome 1
Outcome 2

b)


E
F
G
H
P
Q
R
S
egpr
fhqs
Outcome 3
Outcome 4

c)

Stage 1	Stage 2	Test
Learned Predictiveness		
AX - O1	AW - O3	A
AY -O1	BZ - O4	B
BX - O2	CX - O3	C
BY - O2	DY - O4	D
CW - O1		W
CZ - O1		X
DW - O2		Y
DZ - O2		Z
Blocking		
E - O3	EP - O3	P
F - O3	FQ - O4	Q
G - O4	GR - O3	R
H - O4	HS - O4	S

Figure 3.18: Adaptation of Study 1 design to the Honey network. a) Stage 1 of learned predictiveness; b) Stage 2 of blocking; c) Design Table for Study 1

When AX, AY, CW and CZ were followed by the same outcome (Outcome 1), they become linked to the same hidden unit (acwxyz), and when BX, BY, DW and DZ were followed by the same outcome (Outcome 2), they were also linked by the same hidden unit (bdwxyz), see Figure 3.18a. As A and C were represented by the same hidden unit, both of these stimuli will acquire equivalence, but it will be distinct from B and D, which are represented by a different hidden unit. Additionally, W, X, Y and Z will be the least distinct as they will be represented by both hidden units. Translating this back to the design of Study 1, participants will learn more about A to D relative to W to Z as they are more distinct comparatively and this was reflected by the test stage results, where participants rated A, B, C and D higher than W, X, Y and Z.

Turning now to the blocking stimuli, E, P and G and R shared a hidden unit (egpr) as they had the same outcome (Outcome 3) while FQ and HS shared a separate hidden unit (fhqs) as they both signalled a different outcome (Outcome 4), see Figure 3.18b. The Honey network predicts that learning of P and S would not be disrupted because P will activate the (egpr) hidden unit to Outcome 3 and S will activate the (fhqs) hidden unit to Outcome 4. Consequently, there should not be any difference between P/R and Q/S. This was reflected in the test stage ratings as there was no significant difference between the to-be-blocked stimuli (P and S) and control stimuli (Q and R).

Three more blocking studies were conducted to determine if blocking can be observed and consequently, be tested alongside learned predictiveness. However, all three blocking studies found higher ratings for the blocked stimuli than for the control stimuli. This pattern of results observed is comparable to the redundancy effect (Pearce, Dopson, Haselgrove and Esber, 2012) who compared the CR elicited from a redundant stimulus from a blocking and simple discrimination task. According to the Rescorla-Wagner model, in a blocking design, once the associative strength of A+ has approached asymptote, when presented in a compound subsequently (AX+), X will gain no associative strength. In a simple discrimination task, AX+ BX-, the model predicts that A will have the highest associative strength followed by X and lastly B when asymptote has been reached. Therefore, Pearce et al. (2012) predicted that CR from a blocking task will be weaker than from a simple discrimination task. However, their results show that greater responding towards X after blocking rather than simple discrimination, which is comparable to the results observed in Study 1's test stage where the mean ratings of the blocked stimuli from the blocking task was higher than the mean ratings of the irrelevant stimuli from the learned predictiveness task. They have also considered a within-compound association effect but like in Study 3, found no evidence to support this.

Zaksaite and Jones (2020) also found a redundancy effect in their blocking experiments using a food allergist task and discovered that it was related to the lack of inhibitory effects by the blocking stimulus to the blocked stimulus. Their results showed that the redundancy effect is smaller when the blocking stimulus is rated as inhibitory and the strength of inhibition is proportionate to the redundancy effect, where the greater the inhibitory effect, the smaller the redundancy effect. They also demonstrated that when using an alternative task, there were weak inhibitory effects in the blocking stimulus and therefore, suggests that type of task is important when investigating associative learning phenomena. Furthermore, the redundancy effect highlights associative models such as the Rescorla-Wagner (1972) model to overestimate the magnitude of blocking, as it predicts that CR to a blocked cue will be lower than an irrelevant cue.

Maes et al. (2016) reported 15 blocking experiments that failed to reproduce the effect despite replicating the procedural methods almost identically to previous studies. They argue that blocking is highly parameter-dependent but presently lack the knowledge to identify which parameters are influential. Moreover, all their studies employ non-human animals, and makes it difficult to conclude that the findings of the four blocking studies here replicate their results. Soto (2018) argues that the reason why Maes et al. (2016) failed to find blocking is because ten out of fifteen of the studies reported used stimuli from the same modality that resulted in a *configural* stimulus processing and thus, exhibited a weak blocking effect. Wagner (2003) has argued that cues which are highly dissimilar (e.g., coming from different modalities) would be more likely to be processed in an *elemental* manner and consequently, produce a greater blocking effect than a CS that is highly similar.

The stimuli used in this experiment were names of food in white text on a grey background and the thing that discriminates them from one another is their own semantic meaning and the letters that were used to spell out the words were different. Additionally, in the learned predictiveness task, the outcomes were different in Stage 1 and 2 but remained the same for all the blocking tasks. Perhaps the conditions to obtain learned predictiveness are less constrained than blocking, and blocking requires an even more specific parameter as claimed by Maes et al. (2016). Therefore, in order to obtain a blocking effect, the CS could be more distinctive such as using images of foods rather than just their names. Indeed, Le Pelley et al. (2014) found that blocking was greater for target cues with a high semantic salience.

Alternatively, participants recruited in all four studies may have had a predisposition to think configurally. A post hoc inspection of surnames reported on participant ethics forms, revealed that a majority of participants had surnames commonly associated with East Asian family names. According to the Hofstede database, most countries from East Asia are collectivistic and collectivistic countries have a tendency to think/learn holistically (Nisbett et al., 2001). In Study 1, there were approximately 67% participants from a collectivistic nation, approximately 29% in Study 2, approximately 78% in Study 3 and approximately 59% in Study 4. Therefore, there is a possibility that participants' inherent approach to think and learn holistically may have influenced how the associations between stimuli and outcomes were processed. In the following chapters, the effect of different thinking styles (analytical or holistic) will be formally investigated.

In conclusion, learned predictiveness and blocking could not be found when tested within the same paradigm. It was hypothesized that the learned predictiveness component was interfering with blocking, but Study 2 found no evidence to support this. Study 3 found no support that the inability to generate blocking was due to a within-compound association. In Study 4, a simple blocking design was employed and there was still no blocking found. The lack of blocking was due to participants having learned the associations configurally rather than elementally and thus, show comparable ratings for the blocked and control stimuli.

Chapter 4:

Study 5: Relationship between Personality Traits and Cultural Orientation in Latent Inhibition and Learned Predictiveness

4.1.i: Introduction

The studies reported in Chapter 3 produced an effect of learned predictiveness (Study 1) and while four blocking studies were conducted, no evidence of blocking was found in any of them. As one of the goals of this thesis is to determine if the same individual can demonstrate two associative learning phenomena to ultimately compare the magnitude of their effects and subsequently determine if they co-vary with personality traits, the two effects that will be investigated in this chapter were learned predictiveness and latent inhibition. To recap, learned predictiveness refers to a bias in learning about stimuli that have, in the past, been established as good predictors of different outcomes to those that are currently being learned about. Latent inhibition refers to the impaired learning of a stimulus-outcome association if that stimulus was previously presented without an outcome.

According to the Mackintosh (1975a) theory, see Equation 2 (Chapter 1), when the CS (A) was presented with no outcome during the pre-exposure phase, the value of α for A will decrease. This is because the surrounding environment also predicts that nothing happens which renders A to not be a relatively better predictor of nothing, and thus, Equation 2b predicts that α will be low. Therefore, when it is paired with an outcome (shock), the low value of α will cause the increment of associative strength on any trial to be relatively small. On the other hand, the Pearce-Hall model, see Equation 3, predicts that attention to A will decline when it is repeatedly presented by itself because it is a predictor of *nothing*. Thus, when paired with a shock, the associability of A will be low compared to a novel stimulus (B).

A key difference between the Mackintosh theory and the Pearce-Hall model is that the former predicts that more attention will be allocated to the stimulus that has a history of being *predictive* while the latter predicts that more attention will be allocated to the stimulus that has a history of being associated with *surprising* outcomes. However, the Mackintosh theory does not provide a full account of latent inhibition (see Chapter 1.9). At the same time, the Pearce-Hall model does not predict learned predictiveness. Hybrid models (Esber and Haselgrove, 2011; Le Pelley, 2004) have been introduced to resolve these limitations. The Le Pelley (2004) hybrid model involves multiplying the Rescorla-Wagner summed error term with an α that behaves like the Mackintosh attention mechanism and the σ that behaves like the Pearce-Hall attention mechanism. This model would then predict a mild correlation between latent inhibition and learned predictiveness as the Mackintosh theory can account for learned predictiveness and also, to a certain extent, latent inhibition while the Pearce-Hall model predicts latent inhibition. Furthermore, both of these effects are a function of the strength of the association between the CS and subsequent events, and thus would likely be correlated to some degree. On the other hand, the Esber-Haselgrove (2011) hybrid model would predict no correlation between latent inhibition and learned predictiveness. This is because the model provides separate accounts of these effects.

According to this model, one component drives increases in the salience of a cue as a function of it consistently predicting an outcome (i.e., more attention is paid to the relevant stimulus than the irrelevant stimulus in a learned predictiveness task), and the mechanism that drives this component is the net associative strength between the cue and the outcomes. A second component of the model drives decreases in the salience of a cue and is a function of the associative strength between the context and the cue (cf. Wagner, 1978; 1981). When a cue is well associated with a context its salience is predicted to be low. Consequently, there is little overlap in the associative structure of the mechanisms responsible for learned predictiveness and latent inhibition in this model, and therefore little reason to expect that these two effects would correlate.

In the previous chapter, it was proposed that a bias towards configural processing was a potential reason why blocking could not be generated. Studies have found that an individual is flexible in processing either elementally or configural and this can be dependent on the design of the task and the instructions given (see Melchers et al., 2008 for review). The associative learning theories and hybrid models mentioned in this chapter so far have been elemental theories as they share the assumption that when a compound of stimuli is being conditioned, each stimulus of the compound can enter into an independent association with the reinforcer. On the other hand, configural theories assume that stimuli presented in compounds are processed as a single unitary representation and enter into a single association with a reinforcer. Therefore, configural theories such as the Pearce (1994) connectionist approach and the Honey network (Honey, Close and Lin, 2010) predict a smaller blocking effect and no blocking effect respectively. Individualistic cultures have been shown to process information elementally or analytically and collectivistic cultures have been shown to process information configurally or holistically (for review, see Nisbett, Peng, Choi, Norenzayan, 2001). For example, when asked to describe the scenes of an underwater themed cartoon, Masuda and Nisbett (2001) found that participants from America (individualistic country) were more detailed and object-oriented while participants from Japan provided description of both the background and objects within the scene. However, the extent of this divergent thinking across cultures has yet been investigated in the context of associative learning.

Personality traits have been demonstrated to be stable across time and situations (Maltby et al., 2017). Thus, if there indeed was a cultural variation in latent inhibition and/or learned predictiveness, any effects of personality should be consistent in both cultures. Previous literature has found that individuals high in schizotypy show attenuation to latent inhibition and learned predictiveness (see Chapter 2.5 for more detailed explanation). However, these findings have been mixed. While most evidence seems to indicate that the positive (unusual experiences) sub-dimension of the O-LIFE (Evans et al., 2007; Granger et al., 2016; Gray et al., 2002) mediates the disruption in latent inhibition, like its schizophrenia counterpart (Baruch et al., 1988a; Cohen et al., 2004), the details of this attenuation is inconsistent. The unusual experiences subscale has been associated with quicker learning to the preexposed cue, resulting in reduced latent inhibition (Evans et al., 2007; Granger and Young, 2012) but it has also been implicated in the slower learning to the preexposed cue, resulting in enhanced latent inhibition (Granger et al., 2016). Moreover, enhanced latent inhibition has also previously been associated with the negative dimension of schizophrenia (Cohen et al., 2004). Furthermore, Schmidt-Hansen, Killcross and Honey (2009) found that the reduction in latent inhibition is associated with unusual experiences only when there are ten preexposed cues rather than twenty preexposed cues. Also, Gray et al. (2002) found an association between reduced latent inhibition and cognitive disorganization and impulsive nonconformity.

Research has also found that latent inhibition is mediated by trait anxiety (Braunstein-Bercovitz, 2000) and openness from the Big 5 (Peterson and Carson, 2000). With regards to learned predictiveness, the disruption has been associated with unusual experiences (Le Pelley et al., 2010) and introvertive anhedonia (Haselgrove et al., 2016), while Granger (2017) found no effect of schizotypy. However, to the best of our knowledge, there has been no systematic study of the relationship between learned predictiveness and the Big 5

The first aim of this study is to reproduce latent inhibition and learned predictiveness within the same participant. From the studies presented there have been many studies examining latent inhibition but a substantially smaller amount relating to learned predictiveness. This study, therefore, aims to fill that gap in knowledge. Due to the divergent thinking styles exhibited by the individualistic and collectivistic cultures, there may be a difference in the magnitudes of learned predictiveness and latent inhibition demonstrated by both groups. Hence, this study also aims to determine if there are cultural differences in learned attention tasks.

Attenuation in latent inhibition has been shown to be related to unusual experiences, cognitive disorganization and impulsive nonconformity. Moreover, disruption in learned predictiveness has been shown to mediate unusual experience and introvertive anhedonia. Thus, a second aim of this study is to determine which subscale of schizotypy (as measured with the O-LIFE) plays a role in mediating latent inhibition and learned predictiveness.

Latent inhibition has also been shown to be mediated by trait anxiety and openness. While no studies citing the effects of trait anxiety and the Big 5 personality traits could be found for learned predictiveness, indirect comparisons could be made from the WCST (see section Chapter 2.7 for detailed explanation). Impaired performance is related to trait anxiety (Topçuoğlu et al., 2009), schizotypy (Lenzenweger and Korfine, 1994), extraversion (Campbell et al., 2011), agreeableness (Jensen-Campbell, 2002). Therefore, a third aim of this study is to determine which, if any, personality traits will show a mediating effect on latent inhibition and learned predictiveness.

Finally, it is predicted that latent inhibition and learned predictiveness can be observed within the same individual. However, the magnitude of these effects may differ between the individualistic and collectivistic group. Furthermore, this study predicted that individual differences would play a role in mediating learning as previous studies have found schizotypy (Evans et al., 2007; Granger et al. 2016; Haselgrove et al., 2016; Le Pelley et al., 2010), anxiety (Braunstein-Bercovitz et al., 2000; 2001) and the Big 5 (Peterson and Carson, 2000) to mediate attentional learning.

4.2: Methods

4.2.i: Design

Participants took part in both the learned predictiveness and latent inhibition task (order of presentation was counterbalanced across participants) during the same session. Participants were presented with both preexposed and non-preexposed cues in the latent inhibition task and both the relevant and irrelevant stimuli in the learned predictiveness, which was considered a within-subject design. However, participants were also separated into individualistic and collectivistic groups when analysing their data, which made this culture group a between-subjects variable. Therefore, the study described in this chapter was a mixed-design study.

Latent inhibition: The design of Granger et al.'s (2016) latent inhibition procedure was employed, see Figure 4.3. The manipulated variable was the exposure of cues (preexposed vs. non-preexposed). The dependent variable was the reaction times towards both the preexposed and non-preexposed cues during Stage 2. It was expected that reaction times for the non-preexposed cues will be faster than the preexposed cues.

Learned Predictiveness: The design of Le Pelley and McLaren's (2003) study was employed (See also Study 1 – Learned predictiveness trials), (see Table 4.1). The manipulated variable was the relevance of the cues (relevant vs. irrelevant) during Stage 1, and the dependent variable was the correct response obtained from Stage 1 and 2 and, most importantly, the rating scores obtained from the test phase. It was expected that when the cues were good predictors (relevant) of an outcome during Stage 1, the rating scores of the cues during the test phase will be higher than when the cues were bad predictors (irrelevant) during Stage 1. We followed Le Pelley and McLaren (2003) design, and thus included in Stage 2, 'novel' stimuli not trained in Stage 1 which were consistently paired with the same outcome (EF – O3, GH – O4, IJ – O3, KL – O4).

By providing final test of compounds IJ and KL, relative to novel compounds EH and FG, we can determine the success (or otherwise) of pairing in Stage 2.

Questionnaires: Participants were given the OLIFE (Mason and Claridge, 2006), the Goldberg's bipolar measure of the Big 5 personality dimensions (Goldberg, 1992) and the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA) developed by Ree, MacLeod, French and Locke (2008) after the two behavioural tasks. The presentation of these questionnaires was randomised using Qualtrics' randomiser.

Table 4.1: Design table as in Le Pelley and McLaren (2003). The letters A, B, C, D, E, F, G, H, I, J, K, L, V, W, X, Y represented the foods while Outcomes 1 to 4 represent the allergies.

Stage 1	Stage 2	Test
AV - O1	AX - O3	AC
BV - O2	BY - O4	BD
AW - O1	CV - O3	VX
BW - O2	DW - O4	WY
CX - O1	EF - O3	EH
DX - O2	GH - O4	FG
CY - O1	IJ - O3	IJ
DY - O2	KL - O4	KL

4.2.ii: Participants

An aim of this study was to conduct a simple moderation analysis to determine whether culture moderates the effects of personality traits on learned predictiveness and latent inhibition. As a general rule of thumb, more than 200 participants should be collected when conducting this analysis (Kline, 2011). 267 students (115 University of Nottingham UK, and 152 University of Nottingham Malaysia Campus) participated in this study. There were 46 males and 221 females. The age of the participants ranged from 18 to 27 years old, (M = 19.74, SD = 1.90). Participants were recruited through the school's Research Participation Scheme, recruitment posters and word of mouth. First year psychology undergraduates were compensated with course credit and the rest of the participants were compensated with Ringgit Malaysia 10. Participants had either normal or corrected-to-normal vision. This study also adhered to the ethical guidelines of the School of Psychology in the Malaysian Campus.

4.2.iii: Apparatus

An iMac with a 21.5-inch screen (UK campus) and a HP desktop with a 19-inch screen (Malaysia campus) with Psychopy (version 1.9; Peirce, 2019) installed were used to present stimuli to participants, record responses and control the experimental events. Participant's responses were recorded using a mouse (wired magic mouse in the UK campus and HP wired mouse in the Malaysia campus). The data obtained were analysed using Microsoft Excel (data treatment), SPSS (t-tests and ANOVAs), RStudio (polychoric correlations), JASP (linear regression and Bayesian linear regression) and Jamovi (reliability analysis and simple moderation analysis).

4.2.iv: Materials

Latent Inhibition: The stimuli were white capital letters in Arial font presented for 1000 ms each on a grey background. The preexposed and non-preexposed stimulus letters were "S" and "H". One of the letters served as the preexposed cue while the other served as the non-preexposed cue, counterbalanced across participants. The target (outcome) was the letter “X”, with non-target letters D, M, T, V.

Learned Predictiveness: The 16 foods used were: [apple, asparagus, banana, berry, broccoli, carrot, date, garlic, lettuce, mushroom, onion, orange, pea, pepper, potato, tomato] and these presented as images. The four types of allergic reactions were: itch, dizziness, nausea and sweating. The food items and allergic reactions were randomly assigned to Cues A-Z and Outcome 1-4 respectively (see Table 4.1).

Questionnaires

The O-LIFE questionnaire (Mason and Claridge, 2006) was used to assess individual schizotypy. There are 4 subscales in the O-LIFE with 104 questions. The O-LIFE maps on the same multi-dimensional structure of schizophrenia as it can assess positive, negative and disorganized symptoms. Example statements can be seen in Appendix A. Participants can choose either “yes” or “no” to the statements or choose to skip.

The Goldberg’s Transparent Bipolar Inventory (Goldberg, 1992) was used to assess the Big 5 personalities traits (openness (O), conscientiousness (C), extraversion (E), agreeableness (A) and emotional stability (ES)) in an individual. The questionnaire consists of 70 human traits placed on a 9-point scale, refer to Appendix B (O = unanalytical vs. analytical; C = careless vs. thorough; E = introverted vs. extraverted; A = cold vs. warm; ES = tense vs. relaxed).

The State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA) developed by Ree, MacLeod, French and Locke (2008) was used as it provided a measure of pure anxiety, by being better than the STAI in discriminating between the symptoms of anxiety and depression. The STICSA consists of two scales, the state and trait anxiety; each scale consists of 21 self-report items. The STICSA state scale assesses how respondents “feel right now, at this very moment, even if this is not how you usually feel," whereas, the trait scale assesses "how often, in general, the statement is true of you." Each item is rated on a 4-point Likert scale, ranging from 1 (not at all) to 4 (very much so), see Appendix C for example statements.

4.2.v: Procedure

4.2.v.a: Latent Inhibition (Letter Prediction Task)

The experiment began with an information screen containing instructions for the task (see Figure 4.1). In the pre-exposure stage, participants were presented with a string of letters (preexposed stimulus letters (H and S) and filler letters (D, M, T, V)) and were asked to say out loud each of the letters that appeared on the screen. The letters were presented for 1000ms and had a 50 ms inter-stimulus interval (ISI) between each other.

Following Stage 1, a second set of instructions was presented to the participants, see Figure 4.2, before the test stage began. In the test stage, the preexposed and non-preexposed cues were each presented 20 times followed by the target letter "X". Intermixed with these pairing were also 20 non-cued presentations of X during which the target was preceded by one of the 4 filler letters, each of which preceding the target 5 times. There was a total of 64 presentations of each of the filler letters throughout the test phase. All the letters were presented for 1000 ms with an ISI of 50 ms. Participants were required to press the spacebar when X appeared on the screen or if they could predict when X would appear as the next letter in the sequence, see Figure 4.3 for an illustration of the test stage procedure.

In this task I want you to watch the sequence of letters appearing on the screen. Your task is to say each of the letters out loud as you see them appear. This task will last about 3mins. When this task ends, you will be given a new set of instructions.

Press any key when you are ready to start the experiment.

Figure 4.1: Stage 1 instruction for latent inhibition task in Study 5

In this task I want you to watch the sequence of letters appearing on the screen. Your task is to try and predict when a letter 'X' is going to appear. If you think you know when the 'X' will appear then you can press the space bar early in the sequence, that is before the 'X' appears on screen. Alternatively, if you are unable to do this please press the spacebar as quickly as possible when you see the letter 'X.' There may be more than one rule that predicts the 'X.' Please try to be as accurate as you can, but do not worry about making the occasional error.

If you understand your task and are ready to start press the spacebar to begin.

Figure 4.2: Test stage instructions for latent inhibition task in Study 5

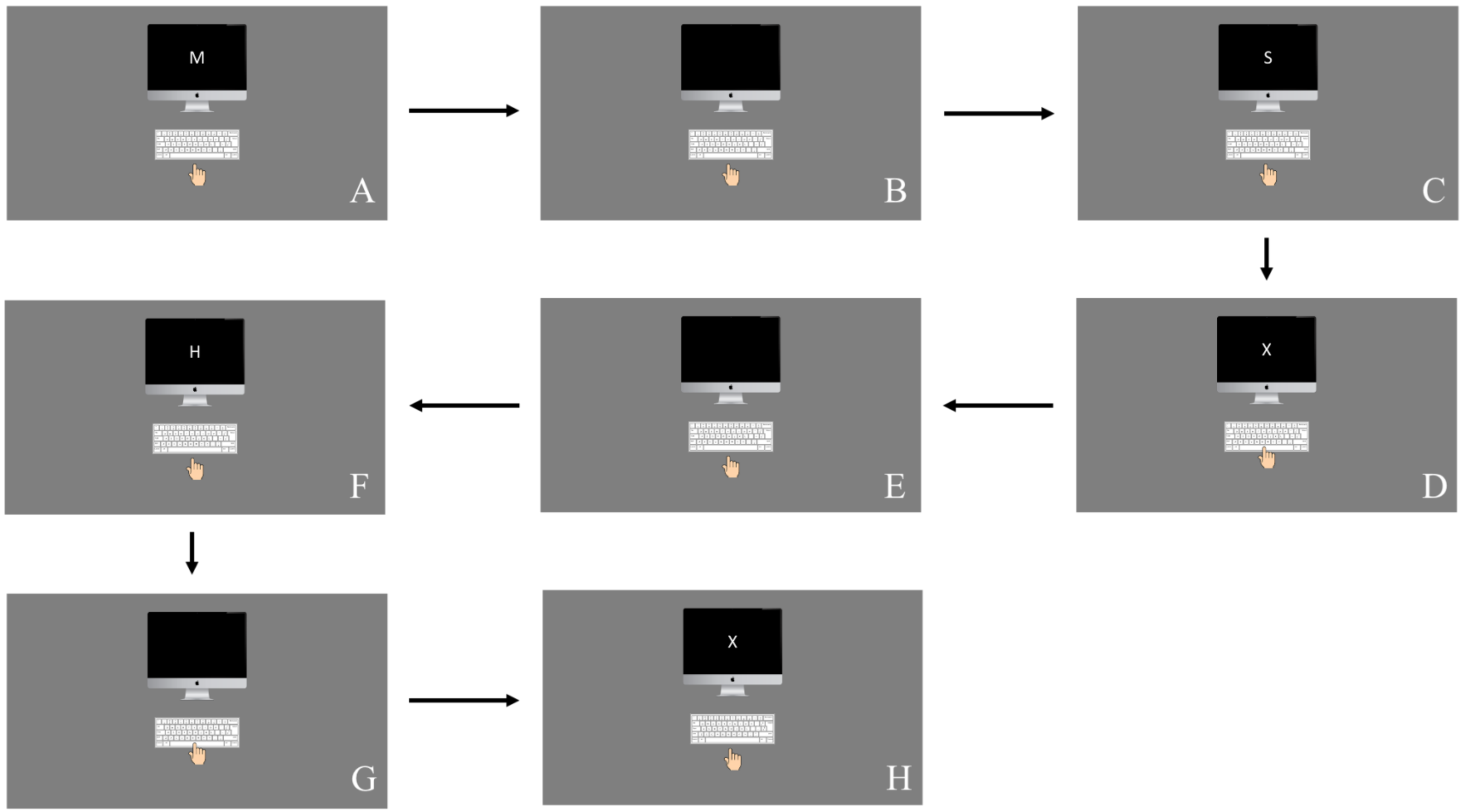


Figure 4.3: Image A shows a filler trial presented for 1000 ms and Image B shows an ISI of 50 ms. Image C shows the preexposed stimulus (S). When the target letter “X” appears (Image D), participants press the spacebar as quickly as possible. This is then followed by an ISI of 50 ms. Image F shows the non-preexposed stimulus (H). If participants predict that “X” would follow subsequently after the letter “H” (Image H), they can also press the spacebar (Image G).

4.2.v.b: Learned Predictiveness (Food Allergist Task)

The experiment began with an information screen containing instructions for the task (Figure 4.4).

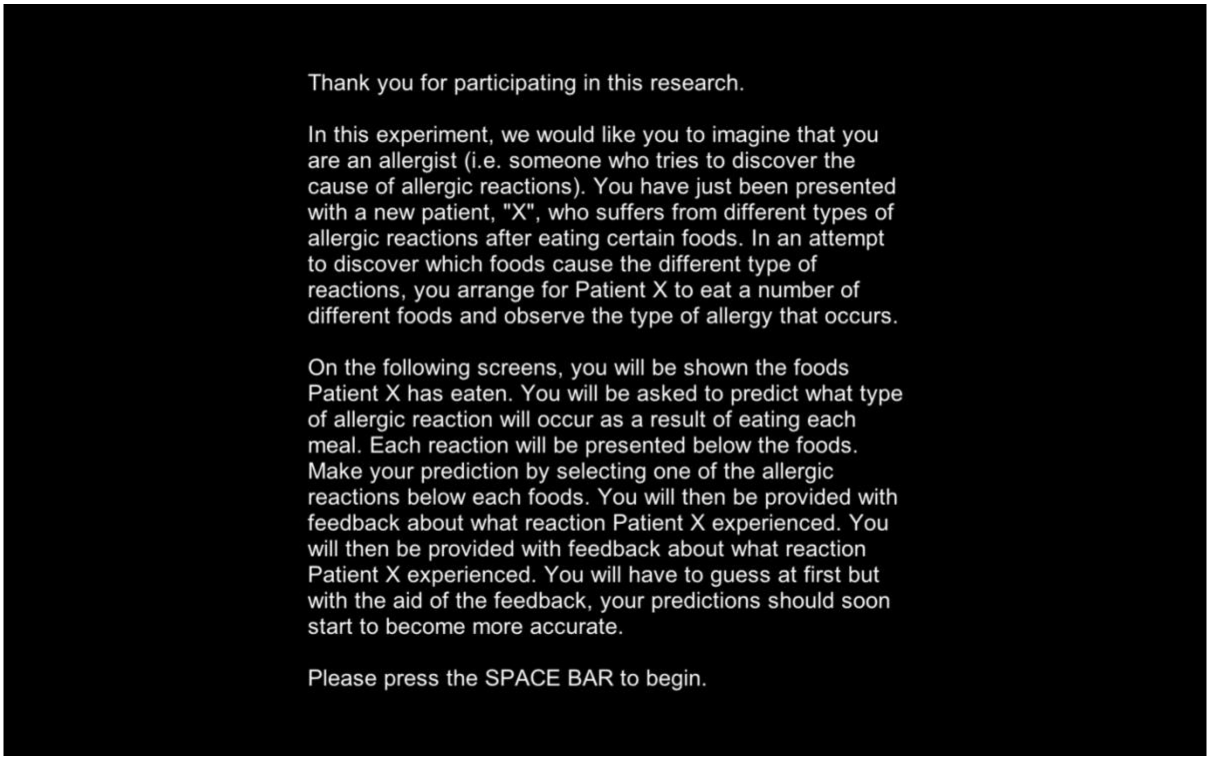
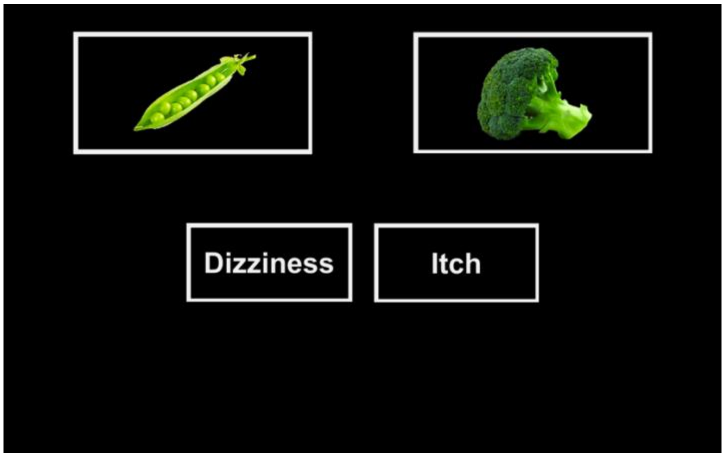


Figure 4.4: Stage 1 instructions for learned predictiveness task in Study 5

On each Stage 1 trial, participants were presented with pairs of foods in compounds (AV, BV, AW, BW, CX, DX, CY or DY) and were required to choose 1 out of 2 possible allergy outcomes (O1 and O2) by using the mouse to click (see Figure 4.5a). This task is self-paced as there was no time limit per trial. They received immediate feedback based on their answers, (Figure 4.5b), for 1500 ms and were then brought to the next trial.

a)



b)

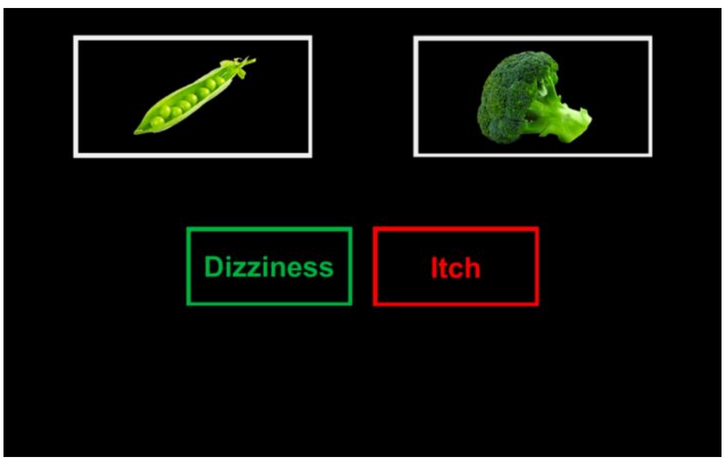


Figure 4.5: a) example of trial in Stage 1; b) example of feedback given in food allergist task

Each type of food compound in Stage 1 was presented 12 times. There was a total of 96 trials. The order of trials was block randomized. The position of the foods on the screen was randomly varied trial to trial.

After Stage 1, Stage 2 began with another set of instructions (see Figure 4.6). Here, participants were presented with new compounds (AX, BY, CV, DW, EF, GH, IJ and KL) and were required to choose 1 out of 2 possible allergy outcomes (O3 and O4 see Table 4.1) by using the mouse to click. The format of the presentation of food items and allergy was exactly the same as in Stage 1. Immediate feedback was also given. The order of the trial types was block randomized and each trial type was presented 6 times. There was a total of 48 trials.

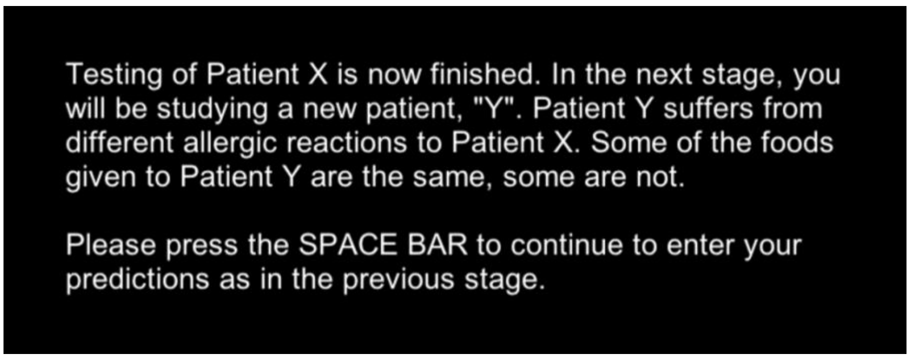


Figure 4.6: Stage 2 instructions for learned predictiveness task in Study 5

At the end of Stage 2, participants were given a new set of instructions where they were asked to rate the individual food items (see Figure 4.7). Four food compounds (AC, BD, VX, WY) were presented in a random order for rating. Participants were required to place their rating for both Allergy 3 and 4 on an 11-point Likert scale (see Figure 4.8). Participants moved to the next food compound after inputting their ratings.

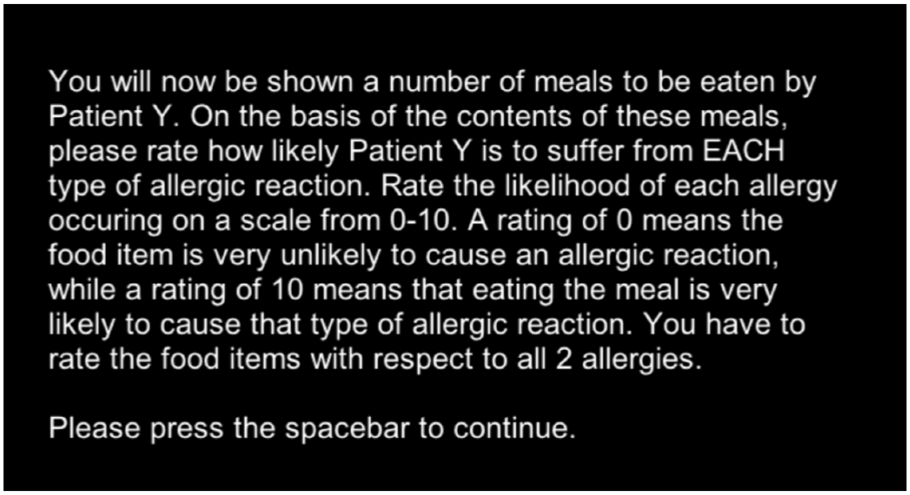


Figure 4.7: Test stage instructions for learned predictiveness task in Study 5

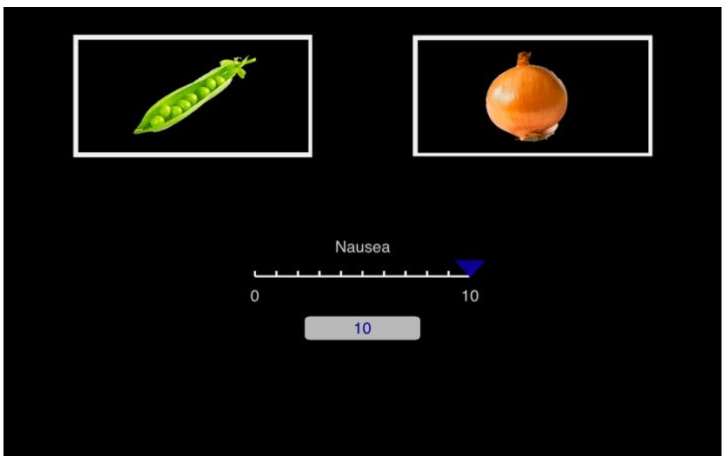


Figure 4.8: Example of test stage trials in food allergist task

4.2.v.c: Questionnaires

At the end of the experimental task, participants were asked to complete 3 questionnaires: O-LIFE, STICSA and Big 5, the order of which was counterbalanced across participants. These questionnaires were administered through Qualtrics, see Appendix A, B and C for screenshots of questionnaires.

4.3: Results

In PART A we will first describe on what basis participants will be removed from analysis. It will then describe how participants were separated into individualistic and collectivistic groups. It will then describe how the behavioural and psychometric data were treated. Next, in PART B, the analysis of the latent inhibition behavioural data will be discussed followed by the learned predictiveness behavioural data. The behavioural data will also be split by culture to analyse. As one of the goals of this study was to determine whether latent inhibition and learned predictiveness effects are related, the reaction times for preexposed and non-preexposed cues from the letter prediction task and the correct responses from Stage 2 of the food allergist task will be analysed using a Pearson's correlation. Participants will also be separated into individualistic and collectivistic groups in this analysis to determine if there are any cultural differences.

After these analyses, the psychometric data will be analysed. The statistical analysis for latent inhibition will be presented first followed by learned predictiveness. Participants will be split into individualistic and collectivistic groups again to determine if there are cultural differences in personality traits predicting latent inhibition (PART C) and learned predictiveness (PART D).

Part A: Data treatment

4 participants were eliminated due to 1 participant not completing 2 questionnaires and 3 participants responding to every trial in the latent inhibition task (i.e., hitting the spacebar for both target and non-target letters). The final n = 263.

To conduct analyses based on culture, participants were separated into individualistic and collectivistic group by their nationality using this analytics website: https://www.hofstede-insights.com/country-comparison/. Hofstede gathered data from IBM employees from over 70 countries to investigate the cultural orientation of individuals from different nations (Hofstede, Hofstede and Minkov, 2005). There were n = 102 participants in the individualistic group, and n = 161 participants in the collectivistic group after sorting.

The individualistic group consists of participants from America, England, Germany, Hungary, Ireland, Italy, Norway and Poland while participants in the collectivistic group were from Bangladesh, China, Cyprus, Philippines, Greece, India, Indonesia, Jordan, Malaysia, Namibia, Oman, Pakistan, Singapore, South Korea, Sri Lanka, Turkey and Vietnam.

A1: Behavioural task

A "latent inhibition score" was obtained by subtracting the non-preexposed (NPE) cue reaction times from the preexposed (PE) cue reaction times. Thus, this latent inhibition score will serve as a measure of how learning about the preexposed stimulus is retarded (slower reaction times) compared to the non-preexposed stimulus (quicker reaction times). All 20 trials were analysed together following the analysis in Granger et al. (2016).

A difference score was calculated for the learned predictiveness test ratings, the stimulus-outcome rating for the outcome which the stimulus *was not* paired with in Stage 2 were subtracted from the ratings for the outcome, which was paired with in Stage 2. For example, if the correct outcome for the stimulus was Outcome 3 in Stage 2, then the equation would be ratings for Outcome 3 – ratings for Outcome 4; and if the correct outcome was Outcome 4, it would be Outcome 4- Outcome 3, see Equation 4. The ratings for each relevant stimulus (A/B/C/D) were then averaged to provide an overall "relevant" score and the same for the irrelevant stimuli (V/W/X/Y) to provide an overall "irrelevant" score.

A2: Psychometric data

As mentioned previously, state anxiety is a transient emotion while trait anxiety is relatively stable over time. We were interested in the trait dimension as it would provide a more accurate account of how it would affect learning; therefore, only the scores from the trait dimension of STICSA will be analysed; from now on termed “anxiety”. To meet the assumptions for a multiple regression and moderation analysis, the trait scores for all three questionnaires were transformed. This was first done by ranking each participants’ trait score against other participants and then obtaining a percentile rank value to achieve a normal distribution.

A reliability analysis was conducted for the OLIFE, STICSA and Big 5 questionnaires. The values are as follows: 1) OLIFE ([unusual experiences, introvertive anhedonia, cognitive disorganization, impulsive nonconformity], McDonald’s omega = 0.86, 0.81, 0.85, 0.74 respectively); 2) STICSA (McDonald’s omega = 0.92); 3) Big 5 ([openness, conscientiousness, extraversion, agreeableness and emotional stability], McDonald’s omega = 0.71, 0.77, 0.84, 0.80, 0.79 respectively). According to Feißt et al. (2019), a score of more than 0.80 is considered to have good internal reliability.

To determine if there were any correlations between personality traits and learning, a polychoric correlation rather than a Pearson/Spearman correlation was conducted as it is the most consistent and robust estimator for ordinal variables (see Holgado-Tello, Carrasco-Ortiz, del Barrio-Gándara, and Chacón-Moscoso, 2009 for further justifications). P-values were corrected using the “false discovery rate’ method as it has been shown to increase power to statistical analyses (Korthauer et al., 2019). This analysis was conducted using the psych package in RStudio using the corCi function.

As this is an exploratory study, a parallel approach of using both frequentist and Bayesian linear regressions will be used because Bayesian analysis can discern whether a $p > 0.05$ is the result of a true null effect or an insensitivity of the data to reveal an effect. Dienes (2014) states that a Bayes Factor of < 0.33 is in support of the null hypothesis, a Bayes Factor of > 3 is support of the alternative hypothesis and a Bayes Factor of > 0.33 but < 3 is evidence of a weak or anecdotal effect and requires further data collection. In the context of this experiment, the Bayes Factors inclusion will be reported as they will inform whether the probability of a model with a specific effect is more likely to produce the observed data than the models without that specific effect.

To further determine if culture plays a role in how personality traits affect learning, a simple moderation analysis was used because culture (individualistic/collectivistic) was a dichotomous variable. As the data are nonparametric, this analysis will be conducted by bootstrapping with nsamples = 1000.

Part B: Analysis of behavioural data

B1: Latent Inhibition

Participants’ mean reaction times can range from 0 to 2050 ms. If a participants’ reaction time is less than 1050 ms, they anticipated X. If it is between 1050-2050 ms, participants are responding to X. There were 20 trials with H and S in total and there was a reduction in reaction times for both the preexposed and non-preexposed cues across the trials, see Figure 4.9. This was confirmed by a 2(cues) x 20 (trials) repeated measures ANOVA, where there was a main effect of trials, $F(7.61, 852.70) = 22.80$, $p < 0.001$, $\eta_p^2 = 0.17$. There was also a main effect of cues, $F(1, 112) = 5.08$, $p = 0.03$, $\eta_p^2 = 0.04$, suggesting a latent inhibition effect. There was no significant interaction effect between cues and trials, $F(13.40, 1500.66) = 1.21$, $p = 0.26$, $\eta_p^2 = 0.01$ [4].

Footnote 4: The same task was replicated in children (see Appendix E).

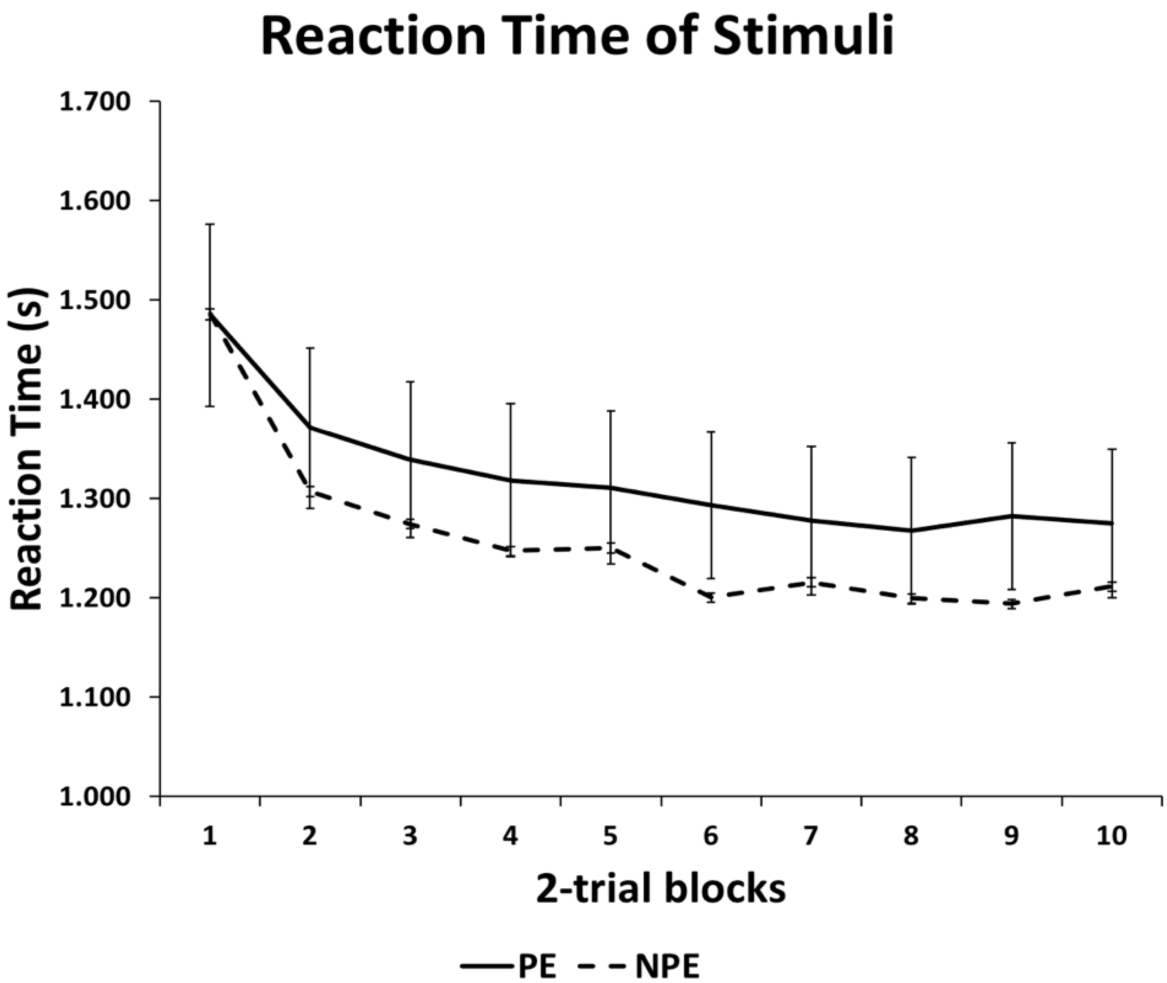


Figure 4.9: Mean Reaction time to the preexposed (PE) and non-preexposed (NPE) across 10 2-trial blocks in Study 5. Error bars represent standard error of mean.

B2: Cultural differences in latent inhibition

There were 20 trials in total and reaction times for both types of cue in the individualistic and collectivistic group showed a reduction across trials, see Figure 4.10. This was confirmed with a 2 (culture) x 2 (cues) x 20 (trials) mixed design ANOVA of reaction times, which revealed no main effect of culture, $F(1, 111) = 2.50$, $p = 0.12$, $\eta_p^2 = 0.02$, but main effects of stimuli, $F(1, 111)$

= 5.68, p = 0.02, η_p^2 = 0.05, and trials, $F(7.53, 835.65) = 21.60$, $p < 0.001$, η_p^2 = 0.16. None of the two-way interactions were significant, largest $F(7.53, 835.65) = 1.39$, p = 0.20, η_p^2 = 0.01. The three-way interaction approached statistical significance, $F(13.59, 1508.79) = 1.65$, p = 0.06, η_p^2 = 0.02. Post-hoc analyses revealed a main effect of trials for both PE and NPE cues in both cultures, largest $F(9.44, 877.74) = 10.69$, $p < 0.001$, η_p^2 = 0.10, suggesting reaction times improved across training in all cues in both groups.

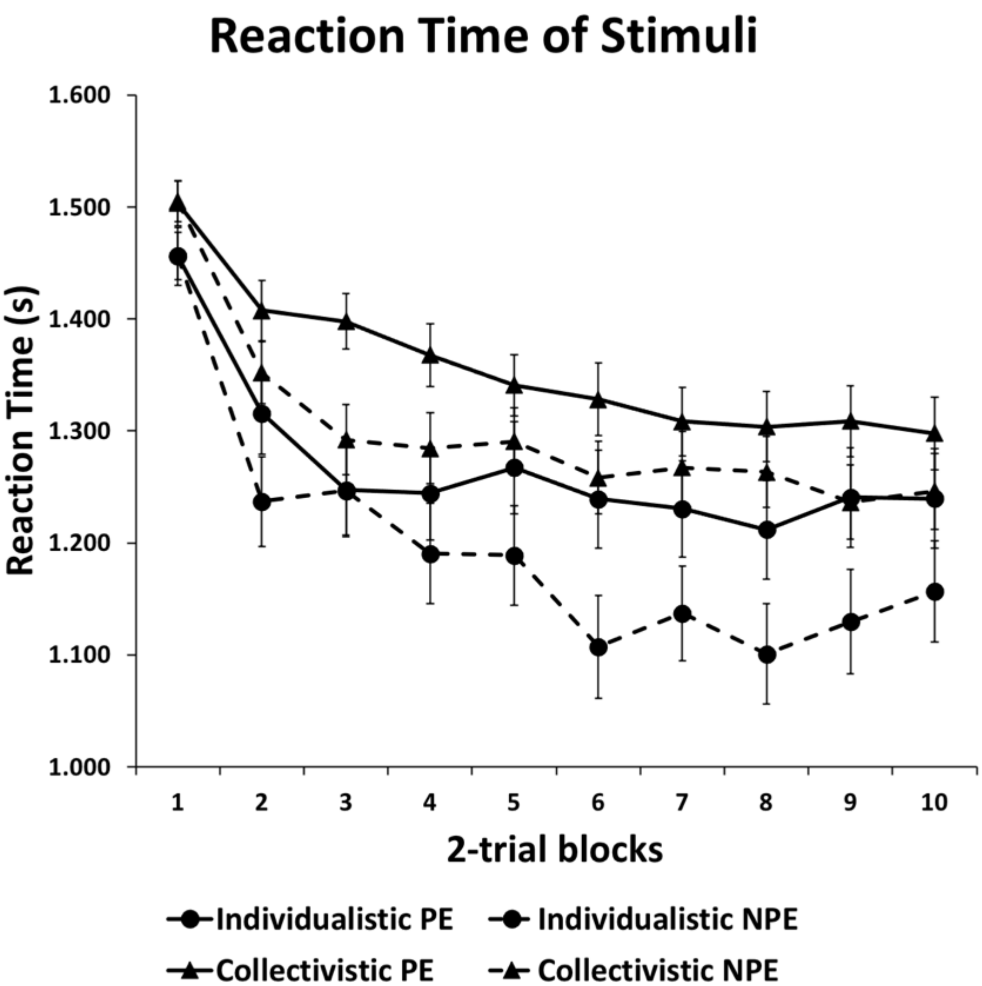


Figure 4.10: Mean Reaction time to the preexposed (PE) and non-preexposed (NPE) cues across 10 2-trial blocks separated by culture in Study 5. Error bars represent standard error of mean.

B3: Learned Predictiveness

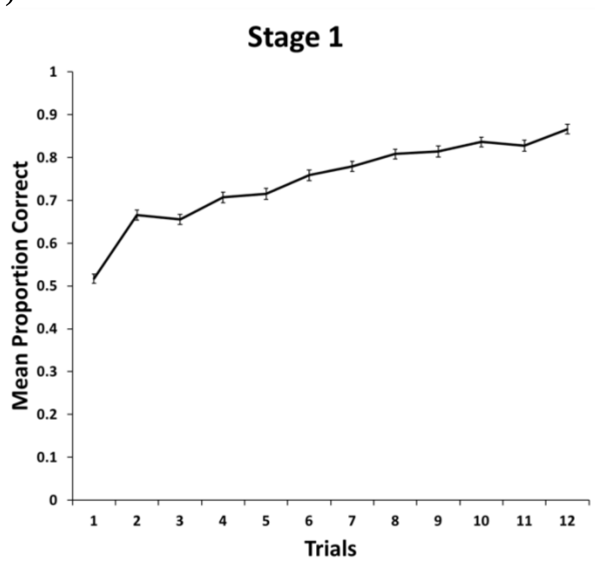
Figure 4.11a shows the mean proportion of correct responses increased steadily across the 12 trials of Stage 1. This was confirmed with a one-way repeated measures ANOVA, which revealed there was a difference in mean proportion correct across trials, $F(8.35, 2188.74) = 117.72$, $p < 0.001$ $\eta_p^2 = 0.31$, indicating that performance improved as training progressed. A one sample t-test was conducted (test value = 0.5) on trial 12 to determine if responding was above chance (50%); there was a significant difference, $t(262) = 31.81$, $p < 0.001$, $d = 1.82$.

As seen from Figure 4.11b, the mean proportion of correct responses to AX/BY/CV/DW and EF/GH/IJ/KL trials during Stage 2 began at chance levels before improving as more trials were experienced. This was confirmed with a 2(stimuli) x 6 (trials) repeated measures ANOVA which revealed a main effect of stimuli, $F(1, 262) = 82.70$, $p < 0.001$, 001 $\eta_p^2 = 0.24$, a main effect of trials, $F(4.53, 1187.79) = 132.70$, $p < 0.001$, 001 $\eta_p^2 = 0.37$. and a significant interaction between stimuli and trials, $F(4.66, 1221.81) = 3.55$, $p = 0.004$, $\eta_p^2 = 0.01$. Post-hoc analyses revealed a main effect of trial for both trial types, largest $F(4.42, 1156.81) = 96.39$, $p < 0.001$, $\eta_p^2 = 0.27$. Further analysis using a simple main effects analysis revealed that accuracies for EF/GH/IJ/KL trials were significantly higher than AX/BY/CV/DW from trial 2 to trial 6 ($p < 0.001$). One sample t-tests revealed that performance in both groups of stimuli on trial 6 was significantly above chance (50%) smallest $t(262) = 15.86$, $p < 0.001$, $d = 0.98$.

Figure 4.12 shows the mean difference score provided by participants in the test stage. A one-way repeated measures ANOVA revealed there was a difference in mean proportion difference in ratings for the four different stimulus types, $F(2.91, 761.30) = 92.07$, $p < 0.001$, $\eta_p^2 = 0.26$. Participants rated the relevant stimuli higher than the irrelevant stimuli and a Bayesian paired samples t-test revealed a significant difference, $t(262) = 2.92$, $p = 0.002$, $BF_{10} = 8.87$, $d = 0.18$ suggesting a learned predictiveness effect.

IJ and KL were explicitly trained as signals of Outcome 3 and 4 respectively and the same compounds were presented again in the test stage. If participants were able to successfully learn the associations in Stage 2 and apply them appropriately in the test stage, then the difference scores for IJ/KL will be higher than EH and FG, which are both made up of one food item previously paired with Outcome 3 and one food item previously paired with Outcome 4. Indeed, EH/FG (M = 0.18, SE = 0.26) had the lowest ratings while IJ/KL (M = 5.71, SE = 0.26) had the highest ratings, $t(262) = -14.90$, $p < 0.001$, $BF_{10} > 100$, $d = -0.92$.

a)



b)

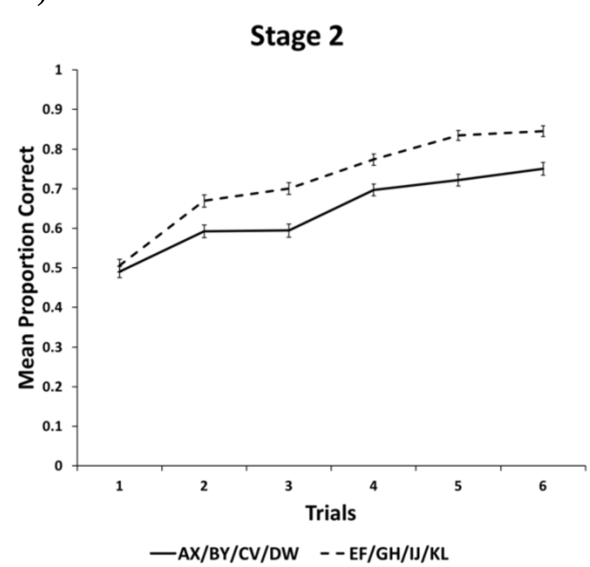


Figure 4.11: Mean proportion correct across trials in Stage 1 and 2 in Study 5. Error bars represent standard error of mean.

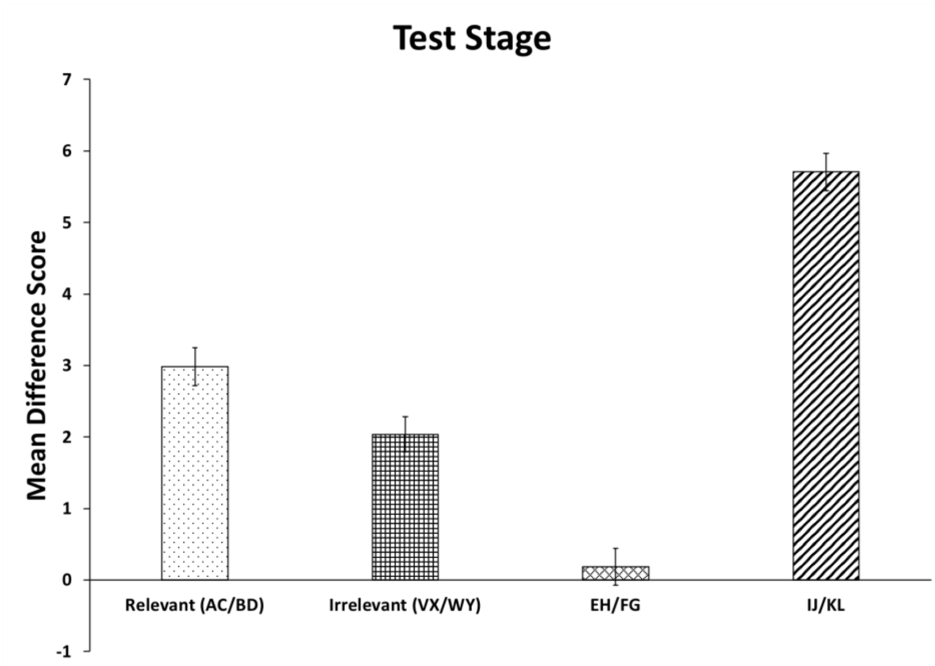


Figure 4.12: Mean difference ratings to the stimuli during the test stage for Study 5. Error bars represent standard error of mean.

B4: Cultural differences in learned predictiveness

Figure 4.13a shows that the individualistic and collectivistic groups mean proportion correct responses increased across the 12 trials. This was confirmed with a 2 (culture) x 12 (trials) mixed design ANOVA, which revealed a main effect of trials, $F(8.35, 2179.05) = 111.21$, $p < 0.001$, $\eta_p^2 = 0.30$, but no main effect of culture, $F(1, 261) = 0.78$, $p = 0.38$, $\eta_p^2 = 0.003$, and an interaction that was approaching significance, $F(8.35, 2179.05) = 1.82$, $p = 0.07$, $\eta_p^2 = 0.01$. The post-hoc analyses revealed a main effect of trial in both groups, largest $F(8.32, 1331.21) = 74.67$, $p < 0.001$, $\eta_p^2 = 0.32$, suggesting that accuracy in both groups improved as more trials were presented. One sample t-tests revealed that performance in both groups on trial 12 was significantly above chance (50%) smallest $t(101) = 18.41$, $p < 0.001$, $d = 1.82$.

Figure 4.13b shows that participants in both groups show a gradual improvement in the mean proportion correct across the six trials of Stage 2. This was confirmed with a 2 (culture) x 2 (stimuli) x 6 (trials) mixed design ANOVA which revealed a main effect of stimuli, $F(1, 261) = 75.17$, $p < 0.001$, $\eta_p^2 = 0.22$, and a main effect of trials, $F(4.54, 1185.97) = 121.88$, $p < 0.001$, $\eta_p^2 = 0.32$. There was no main effect of culture, $F(1, 261) = 0.56$, $p = 0.46$, $\eta_p^2 = 0.002$. There was an interaction between stimuli and trials, $F(4.65, 1214.44) = 3.34$, $p = 0.01$, $\eta_p^2 = 0.01$, but no other two-way interactions nor the three-way interaction was significant, largest $F(4.65, 1214.44) = 1.62$, $p = 0.16$, $\eta_p^2 = 0.01$. The post-hoc analyses revealed a main effect of trial in both groups on both types of trials, largest $F(4.17, 666.99) = 68.80$, $p < 0.001$, $\eta_p^2 = 0.30$, suggesting that accuracy of response in both group improved in both trials types as training progressed. One sample t-tests revealed that performance to both stimuli on trial 6 for both cultures was significantly above chance (50%) smallest $t(101) = 8.01$, $p < 0.001$, $d = 0.79$.

Figure 4.14a shows the mean difference score provided by participants in the test stage for AC/BD/WX/WY trials. A 2 (relevance) x 2 (culture) repeated measures ANOVA revealed there was a significant main effect of relevance, $F(1, 261) = 10.45$, $p = 0.001$, $\eta_p^2 = 0.004$ but no main effect of culture, $F(1, 261) = 0.13$, $p = 0.72$, $\eta_p^2 = 0.001$. There was also no significant interaction effect, $F(1, 261) = 2.77$, $p = 0.10$, $\eta_p^2 = 0.01$. Despite the non-significant interaction effect and main effect of culture, to answer the theoretical aspect of whether there would be a difference between groups in learning about the relevant and irrelevant stimuli, paired samples t-test were conducted.

A paired samples t-test was conducted for the *individualistic* group revealed there was a significant difference between relevant and irrelevant stimuli, $t(101) = 2.98$, $p = 0.002$, $BF_{10} = 14.00$, d = 0.30. A paired samples t-test was also conducted for the *collectivistic* group revealed there was no significant difference between the relevant (M = 2.83, SE = 0.35) and irrelevant (M = 2.31, SE = 0.31) stimuli, $t(160) = 1.30$, $p = 0.10$, $BF_{10} = 0.36$, $d = 0.10$. These findings reveal that only participants from the individualistic group rated relevant stimuli significantly higher than irrelevant stimuli, and the collectivistic group show no difference in ratings.

Figure 4.14b shows the mean difference score provided by participants in the test stage for EH/FG/IJ/KL trials. A 2 (stimuli) x 2 (culture) repeated measures ANOVA revealed there was a significant main effect of stimuli, $F(1, 261) = 203.64$, $p < 0.001$, $\eta_p^2 = 0.44$ and a main effect of culture, $F(1, 261) = 3.16$, $p = 0.008$, $\eta_p^2 = 0.01$. There was also no significant interaction effect, $F(1, 261) = 0.85$, $p = 0.36$, $\eta_p^2 = 0.003$. Post-hoc analyses on the main effect of culture revealed a significant difference for the EH/FG trials between the two cultures, $t(261) = 1.93$, $p = 0.06$, $BF_{10} = 0.80$, $d = 0.24$, but no significant difference for the IJ/KL trials, $t(261) = 0.58$, $p = 0.56$, $BF_{10} = 0.16$, $d = 0.07$. Consistent with the means obtained from all participants, EH/FG (individualistic: M = 0.80, SE = 0.41; collectivistic: M = -0.21, SE = 0.33) had the lowest ratings while IJ/KL (individualistic: M = 5.90, SE = 0.40; collectivistic: M = 5.58, SE = 0.35) had the highest ratings, and a paired samples t-test was conducted between the EH/FG and IJ/KL trials for both individualistic and collectivistic groups and both analyses showed a significant difference, smallest $t(101) = -8.40$, $p < 0.001$, $BF_{10} > 100$, $d = -0.83$.

a)

b)

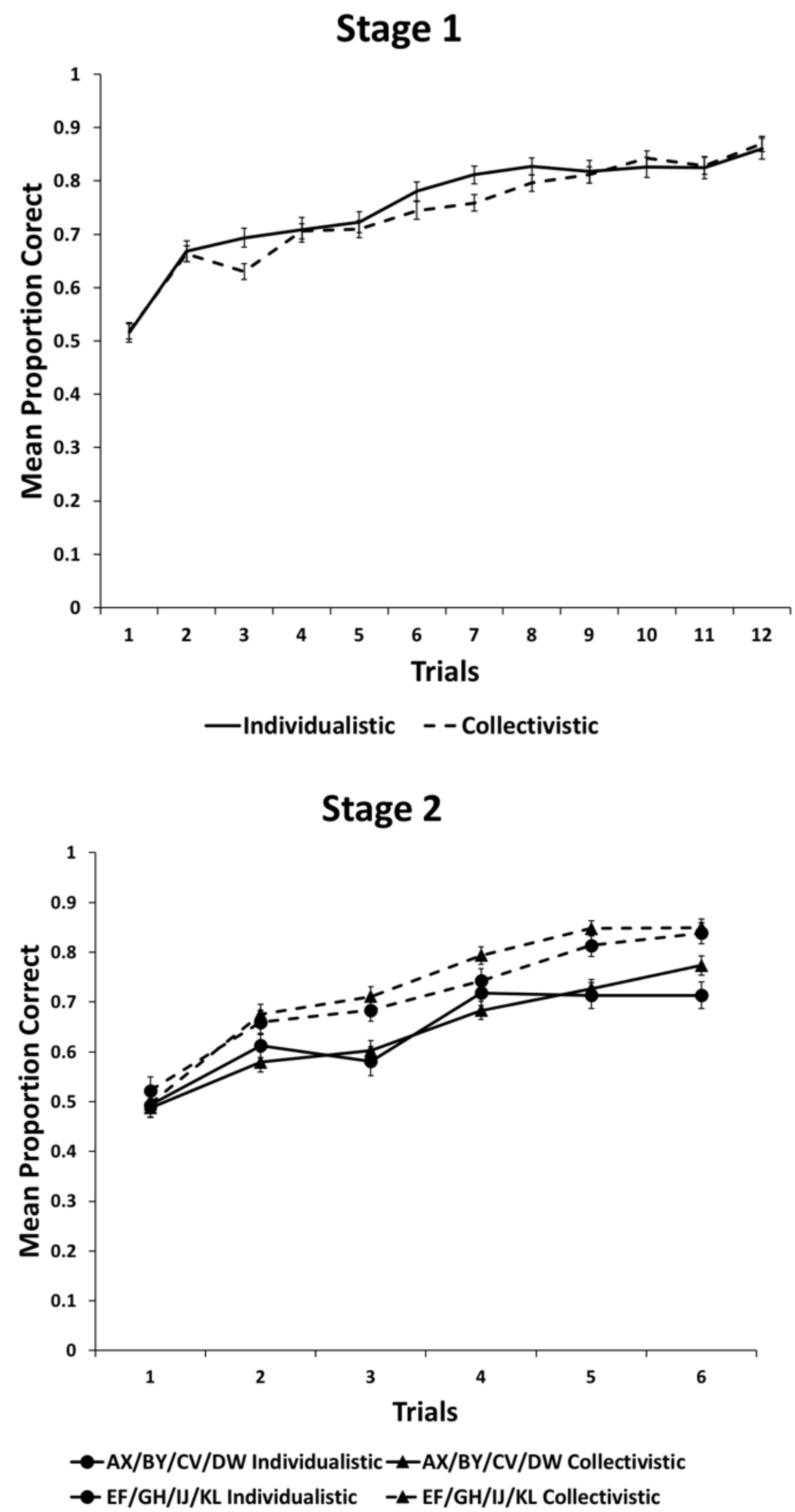
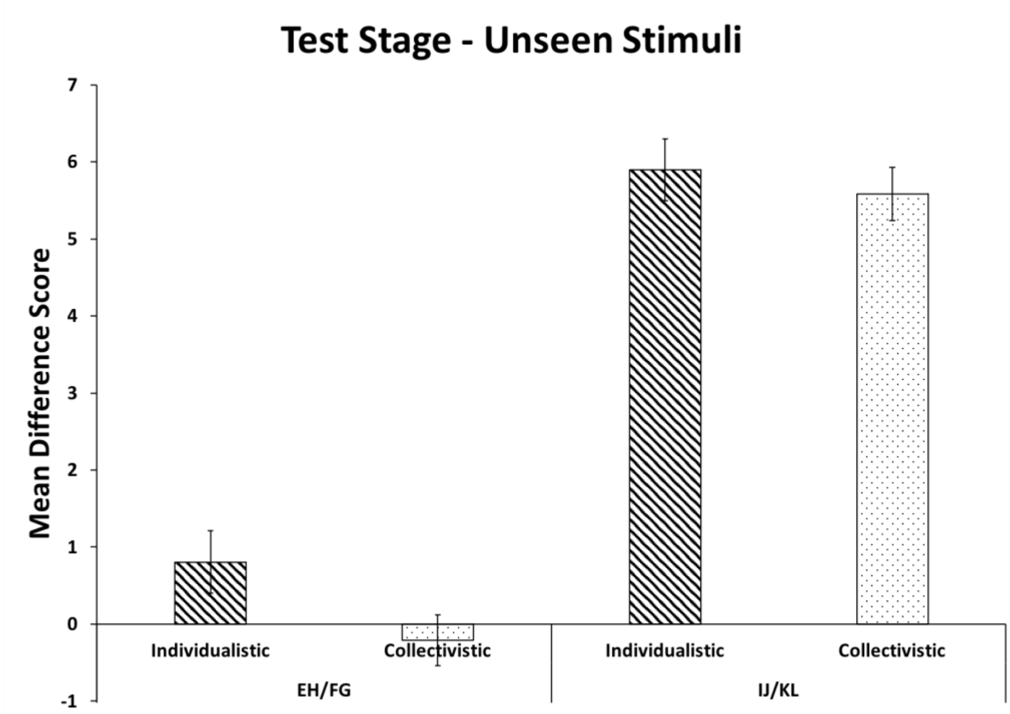


Figure 4.13: Mean proportion correct across trials in Stage 1 and 2 separated by culture in Study 5. Error bars represent standard error of mean.

a)



b)

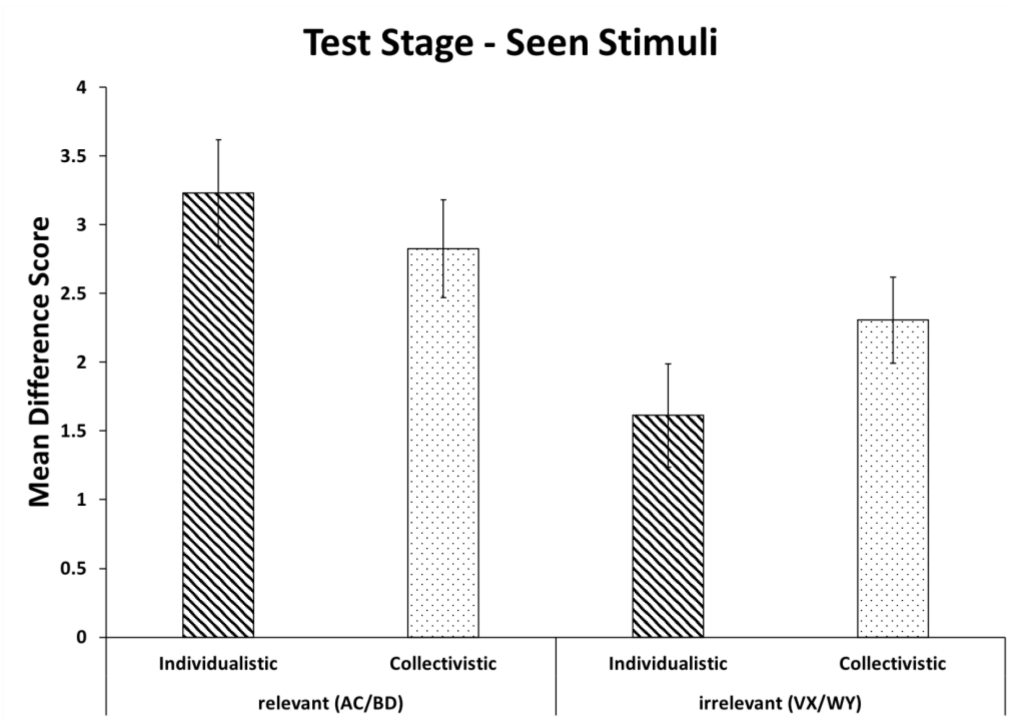


Figure 4.14: Mean difference ratings to the stimuli during the test stage of separated by culture for Study 5, a) AC/BD/VX/WY and b) EH/FG/IJ/KL stimuli. Error bars represent standard error of mean.

B5: The relationship between latent inhibition and learned predictiveness

As seen in Figure 4.11b, the accuracy of EF/GH/IJ/KL (compounds of novel foods) trials were greater than AX/BY/CV/DW (compounds of previously seen foods) trials, which mimics the latent inhibition effect shown in Figure 4.9. Learned predictiveness score and latent inhibition score represents the magnitude of learning that occurred. The learned predictiveness score was obtained by subtracting the mean ratings of the irrelevant stimuli from the relevant stimuli while the latent inhibition score was obtained by subtracting the non-preexposed reaction times from the preexposed reaction times. As shown in Table 4.2a, no correlations were found between the stimuli in learned predictiveness and latent inhibition. When the participants were split by individualistic and collectivistic cultures to conduct this correlation analysis, no correlations were found in both cultures, see Table 4.2b and 6c.

Table 4.2: Bayesian Pearson's correlation matrix for stimuli shown in Stage 2 of the learned predictiveness task and the cues from the latent inhibition task in Study 5. AX/BY/CV/DW trials from the learned predictiveness task consist of stimuli previously shown in Stage 1 while EF/GH/IJ/KL trials consist of stimuli that is not previously shown in Stage 1. Therefore, AX/BY/CV/DW trials are comparable to the preexposed cues from the latent inhibition task and the EF/GH/IJ/KL trials are comparable to the non-preexposed cues from the latent inhibition task. Note: BF10 > 10*, BF10 > 30**, BF10 > 100***

a) All participants, n = 263

		A/B/C/D/V/W/X/Y	E/F/G/H/I/J/K/L	Difference Score	Pre-exposed cues	Nonpre-exposed cues
A/B/C/D/V/W/X/Y	Pearson's r					
	BF_{10}					
E/F/G/H/I/J/K/L	Pearson's r	0.46***				
	BF_{10}	>100				
Difference Score	Pearson's r	0.52***	-0.52***			
	BF_{10}	>100	>100			
Pre-exposed cues	Pearson's r	-0.07	-0.03	-0.03		
	BF_{10}	0.14	0.09	0.09		
Nonpre-exposed cues	Pearson's r	< 0.01	-0.01	0.01	0.66***	
	BF_{10}	0.08	0.07	0.08	>100	
Latent Inhibition Score	Pearson's r	-0.08	-0.02	-0.06	0.34***	-0.48***
	BF_{10}	0.19	0.08	0.12	>100	>100

b) Individualistic, n = 102

		A/B/C/D/V/W/X/Y	E/F/G/H/I/J/K/L	Difference Score	Pre-exposed cues	Nonpre-exposed cues
A/B/C/D/V/W/X/Y	Pearson's r					
	BF_{10}					
E/F/G/H/I/J/K/L	Pearson's r	0.46***				
	BF_{10}	>100				
Difference Score	Pearson's r	0.52***	-0.52***			
	BF_{10}	>100	>100			
Pre-exposed cues	Pearson's r	-0.07	-0.03	-0.03		
	BF_{10}	0.14	0.09	0.09		
Nonpre-exposed cues	Pearson's r	< 0.01	-0.01	0.01	0.66***	
	BF_{10}	0.08	0.07	0.08	>100	
Latent Inhibition Score	Pearson's r	-0.08	-0.02	-0.06	0.34***	-0.48***
	BF_{10}	0.19	0.08	0.12	>100	>100

c) Collectivistic, n = 161

		A/B/C/D/V/W/X/Y	E/F/G/H/I/J/K/L	Difference Score	Pre-exposed cues	Nonpre-exposed cues
A/B/C/D/V/W/X/Y	Pearson's r					
	BF_{10}					
E/F/G/H/I/J/K/L	Pearson's r	0.47***				
	BF_{10}	>100				
Difference Score	Pearson's r	0.49***	-0.55***			
	BF_{10}	>100	>100			
Pre-exposed cues	Pearson's r	-0.09	-0.03	-0.05		
	BF_{10}	0.18	0.11	0.12		
Nonpre-exposed cues	Pearson's r	0.03	0.04	-9.15E-03	0.67***	
	BF_{10}	0.11	0.11	9.93E-02	>100	
Latent Inhibition Score	Pearson's r	-0.14	-0.08	-0.05	0.30***	-0.52***
	BF_{10}	0.44	0.17	0.12	>100	>100

B6: Summary of findings

Latent inhibition was demonstrated in participants from both individualistic and collectivistic culture groups. With regards to learned predictiveness, participants from both cultures learned the stimulus-outcome associations in Stage 1 and 2 successfully. However, while an overall learned predictiveness effect was found, only the individualistic group demonstrated learned predictiveness as revealed from the paired samples t-tests despite the non-significant interaction effect between culture and relevance of stimuli. The results also revealed that there was no correlation between latent inhibition and learned predictiveness and this was still the case after splitting participants by culture.

Part C: Effects of personality traits on latent inhibition

To investigate the relationship between schizotypy, anxiety and the Big 5 with latent inhibition, polychoric correlations was conducted. The reason for choosing a polychoric correlation is because it is the most consistent and robust estimator for ordinal variables (Holgado-Tello et al., 2009). Next, frequentist and Bayesian linear regressions were conducted with the personality traits and subscales as the predictors of response times to the preexposed cues, non-preexposed cues and latent inhibition score. If any personality traits of subscale were found to be significant and whose $BF_{inclusion}$ was either supporting the alternative hypothesis (>3) or anecdotal ($0.33 < BF_{inclusion} < 3$), a simple moderation was conducted.

C1: Schizotypy

Correlation analyses show that introvertive anhedonia was positively correlated with response times to the preexposed cues and the overall latent inhibition score. When participants were split by culture, participants from the individualistic culture showed a positive correlation between impulsive nonconformity and latent inhibition score. Participants from the collectivistic culture showed a positive correlation between introvertive anhedonia and latent inhibition score, see Table 4.3.

To determine whether there is a relationship between schizotypy and latent inhibition, a Bayesian linear regression was conducted. The OLIFE subscales were entered as a predictor of PE and NPE reactions times as well as latent inhibition score (LIScore). There was no significant relationship between the OLIFE subscales and PE and NPE reaction times (PE = $F(4, 258) = 1.94$, $p = 0.10$, $R^2 = 0.03$, adjusted $R^2 = 0.01$; NPE = $F(4, 258) = 0.19$, $p = 0.94$, $R^2 = 0.003$, adjusted $R^2 = -0.01$) but there was a significant relationship between the OLIFE subscales and latent inhibition score, $F(4, 258) = 2.60$, $p = 0.04$, $R^2 = 0.04$, adjusted $R^2 = 0.02$), see Table 4.4 for summary of coefficients.

There was anecdotal evidence of introvertive anhedonia predicting response times to the preexposed cues and also the overall latent inhibition score. That is to say, participants high in introvertive anhedonia show slower learning to the preexposed cues and show a greater effect of latent inhibition. There was also anecdotal evidence of impulsive nonconformity predicting latent inhibition score, reflecting enhanced latent inhibition in participants who are high in this subscale.

This same Bayesian linear regression was repeated after participants were split into individualistic and collectivistic culture. It was found that the OLIFE subscales were not significant predictors of PE, NPE and LIScore for both culture groups, largest $F(4, 97) = 2.24$, $p = 0.07$, $R^2 = 0.08$, adjusted $R^2 = 0.05$), see Table 4.8 for summary of coefficients.

For the individualistic group, there was anecdotal evidence of impulsive nonconformity positively predicting latent inhibition score, meaning that participants in the individualistic group high in impulsive nonconformity show enhanced latent inhibition. For the collectivistic group, there was anecdotal evidence of introvertive anhedonia positive predicting latent inhibition score, meaning that participants in the collectivistic group high in introvertive anhedonia show enhanced latent inhibition.

Table 4.3: Summary of correlations from all participants and split by culture on the relationship between OLIFE subscales and latent inhibition in Study 5. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

OLIFE	PE (r)	NPE (r)	LIScore (r)
All participants (n = 263)			
Unusual Experiences	0.06	0.01	0.06
Introvertive Anhedonia	0.14*	0.01	0.14*
Cognitive Disorganization	0.02	-0.03	0.06
Impulsive Nonconformity	0.07	-0.04	0.13
Individualistic (n = 102)			
Unusual Experiences	-0.06	-0.13	0.09
Introvertive Anhedonia	0.18	0.06	0.14
Cognitive Disorganization	0.03	-0.06	0.10
Impulsive Nonconformity	0.12	-0.10	0.26*
Collectivistic (n = 161)			
Unusual Experiences	0.07	0.01	0.07
Introvertive Anhedonia	0.02	-0.14	0.20*
Cognitive Disorganization	-0.03	-0.06	0.04
Impulsive Nonconformity	0.02	-0.01	0.03

Table 4.4: Summary of OLIFE subscales as coefficients and preexposed cues, non-preexposed cues and latent inhibition score as dependent variables from all participants and split by culture in Study 5. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**PE**		**NPE**		**LIScore**	
OLIFE	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All participants (n = 263)						
Unusual Experiences	0.05	0.15	0.03	0.05	0.02	0.22
Introvertive Anhedonia	0.16*	0.61	0.02	0.05	0.16*	0.99
Cognitive Disorganization	-0.11	0.16	-0.03	0.06	-0.09	0.26
Impulsive Nonconformity	0.09	0.18	-0.04	0.06	0.15*	0.68
Individualistic (n = 102)						
Unusual Experiences	-0.09	0.25	-0.11	0.21	0.02	0.31
Introvertive Anhedonia	0.22	0.53	0.10	0.16	0.15	0.46
Cognitive Disorganization	-0.11	0.14	-0.04	0.14	-0.09	0.32
Impulsive Nonconformity	0.17	0.33	-0.06	0.17	0.27*	2.16
Collectivistic (n = 161)						
Unusual Experiences	0.11	0.11	0.04	0.11	0.08	0.22
Introvertive Anhedonia	0.04	0.08	-0.13	2.90E-01	0.21*	1.31
Cognitive Disorganization	-0.12	0.09	-0.06	0.12	-0.07	0.20
Impulsive Nonconformity	0.04	0.08	0.02	0.11	0.02	0.19

C1.a: Further analysis: Simple moderation analysis

To determine if culture moderates the relationship between impulsive nonconformity and latent inhibition score, a simple moderation analysis was conducted. A simple moderation analysis was chosen because the moderator variable (culture) is dichotomous (i.e., individualistic and collectivistic). As a general rule of thumb, there should be more than 200 participants when running this analysis (Kline, 2011) and there were 263 participants in total.

A significant interaction effect was found between impulsive nonconformity and culture, $\beta = -0.002$, $p = 0.04$, a main effect of impulsive nonconformity ($\beta = 0.001$, $p = 0.03$) but no main effect of culture ($\beta = -0.02$, $p = 0.57$), see Figure 4.15. Participants in the individualistic group who are high in impulsive nonconformity showed enhanced latent inhibition (estimate = 0.002, z-score = 2.99, p = 0.003) while this is not seen in the collectivistic group (estimate < 0.001, z-score = 0.05, p = 0.96), see Figure 4.16 for simple slope plot illustrating this relationship.

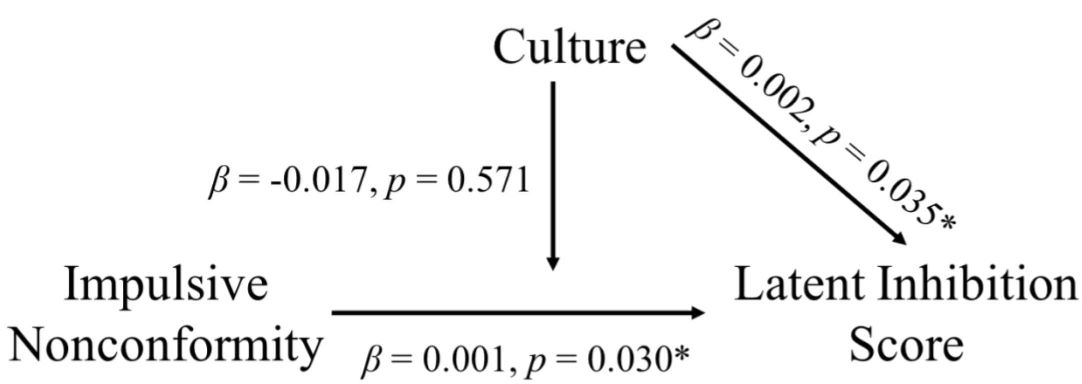


Figure 4.15: Illustration of the relationship between impulsive nonconformity predicting latent inhibition score that is moderated by culture (individualistic and collectivistic) demonstrated in Study 5.

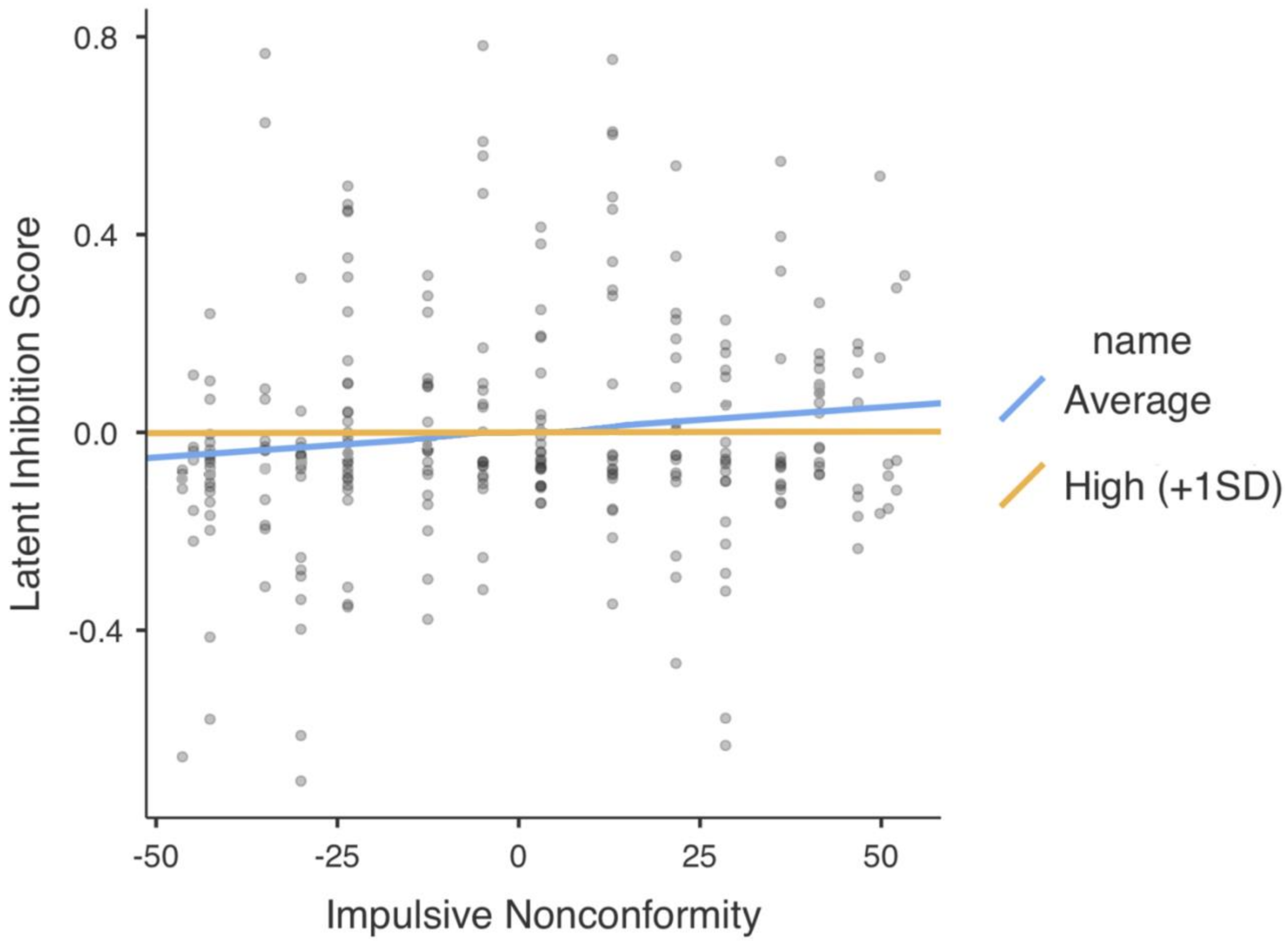


Figure 4.16: Simple slope plot illustrating the relationship between impulsive nonconformity and latent inhibition score in Study 5. Different coloured lines represent different levels of moderator. Grey line (low - -1SD) refers to the individualistic group, and the orange line (high - +1SD) refers to the collectivistic group

C2: Anxiety

As can be seen from Table 4.5, anxiety was not correlated with latent inhibition even after splitting by culture. Bayesian linear regression was conducted with anxiety as a predictor for PE, NPE and LIScore for all participants as well as split by culture, and there was no significant relationship found, largest $F(1, 159) = 1.70$, $p = 0.20$, $R^2 = 0.01$, adjusted $R^2 = 0.004$) [5].

Table 4.5: Summary of correlations from all participants and split by culture of the relationship between anxiety and latent inhibition in Study 5. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Anxiety	PE (r)	NPE (r)	LIScore (r)
All participants (n = 263)	0.03	-0.03	0.07
Individualistic (n = 102)	0.00	-0.02	0.03
Collectivistic (n = 161)	0.03	-0.06	0.10

Footnote 5: To avoid cluttering the results section, the correlation coefficient tables were placed in Appendix G if none of the predictors were revealed to be significant. This was repeated throughout the thesis.

C3: The Big 5

As can be seen from Table 4.6, the Big 5 personality traits were not correlated with latent inhibition even after splitting by culture. Bayesian linear regression was conducted with the Big 5 personality traits as a predictor for PE, NPE and LIScore for all participants as well as split by culture, and there was no significant relationship found, largest $F(5, 257) = 1.76$, $p = 0.12$, $R^2 = 0.03$, adjusted $R^2 = 0.01$.

C4: Summary of findings

Results from the correlation analyses revealed that introvertive anhedonia was positively correlated with the reaction times of the preexposed cue and latent inhibition score. Regression analyses revealed anecdotal evidence of introvertive anhedonia positively predicting reaction times of preexposed cues and latent inhibition score. When split by culture, the correlation analyses revealed that impulsive nonconformity positively correlated with latent inhibition score in participants from the individualistic group. It was also revealed that introvertive anhedonia positively correlated with latent inhibition score in participants from the collectivistic group. The regression analyses revealed anecdotal evidence of participants from the individualistic group high in impulsive nonconformity positively predicting latent inhibition score and this was confirmed with the simple moderation analysis conducted. Meanwhile, participants from the collectivistic group high in introvertive anhedonia positively was revealed to be predicting latent inhibition score. The simple moderation analysis was not reported as none of the main effects and interactions were significant although this is somewhat surprising as the correlation and regression eluded to a potential relationship between introvertive anhedonia and magnitude of latent inhibition. The results of this subsection also revealed that anxiety and the Big 5 personality traits did not play a role in latent inhibition.

Part D: Effects of personality traits on learned predictiveness

To investigate the relationship between schizotypy, anxiety and Big 5 and learned predictiveness, polychoric correlations was conducted. Next, frequentist and Bayesian linear regressions were conducted with the personality traits and subscales as the predictors of the difference scores to the relevant and irrelevant stimuli and learned predictiveness score. If any personality traits of a subscale were found to be significant and whose $BF_{inclusion}$ was either supporting the alternative hypothesis (>3) or anecdotal ($0.33 < BF_{inclusion} < 3$), a simple moderation was conducted.

D1: Schizotypy

The data used in these analyses are from the test stage. As can be seen from Table 4.7, schizotypy was not correlated with learned predictiveness even after splitting by culture. Bayesian linear regression were conducted with the OLIFE subscales as a predictor of difference scores to the relevant and irrelevant stimuli as well as LPScore for all participants was conducted and there was no significant relationship found even after splitting by culture, largest $F(4, 97) = 1.44$, $p = 0.23$, $R^2 = 0.06$, adjusted $R^2 = 0.02$, see Table 4.8 for summary of coefficients.

Impulsive nonconformity was revealed to be a positive predictor of difference scores to the relevant stimuli, reflecting greater learning about these stimuli for participants who have high scores in this subscale. However, the BFinclusion supports the null hypothesis and this is further supported by the previous correlation analysis where impulsive nonconformity was not significantly correlated with difference scores to relevant stimuli. For the individualistic group, there was anecdotal evidence of unusual experiences positively predicting the difference scores to the relevant stimuli. This reflects greater learning of relevant stimuli in individualistic participants high in this subscale. For the collectivistic group, there was anecdotal evidence of collectivistic participants high in impulsive nonconformity showing greater learning of the difference scores to the relevant stimuli was also found.

Table 4.7: Summary of correlations from all participants and split by culture of the relationship between the OLIFE subscales and learned predictiveness in Study 5. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings.

OLIFE	Relevant (r)	Irrelevent (r)	LPScore (r)
All participants (n = 263)			
Unusual Experiences	0.07	0.09	-0.01
Introvertive Anhedonia	0.01	0.07	-0.04
Cognitive Disorganization	0.00	0.06	-0.05
Impulsive Nonconformity	0.10	0.04	0.06
Individualistic (n = 102)			
Unusual Experiences	0.20	0.09	0.08
Introvertive Anhedonia	0.08	0.04	0.03
Cognitive Disorganization	-0.01	-0.01	0.00
Impulsive Nonconformity	0.03	-0.05	0.06
Collectivistic (n = 161)			
Unusual Experiences	0.03	0.05	-0.02
Introvertive Anhedonia	0.01	0.04	-0.02
Cognitive Disorganization	0.01	0.08	-0.05
Impulsive Nonconformity	0.14	0.09	0.06

Table 4.8: Summary of the OLIFE subscales as coefficients and relevant stimuli, irrelevant stimuli and learned predictiveness score as dependent variables in Study 5. *Note*: $p < 0.05^*$, $p < 0.01^{**}$, $p < 0.001^{***}$

Coefficients	**Relevant**		**Irrelevant**		**LPScore**	
OLIFE	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All participants (n = 263)						
Unusual Experiences	0.06	0.11	0.05	0.08	-0.03	0.06
Introvertive Anhedonia	0.04	0.09	0.03	0.07	-0.02	0.07
Cognitive Disorganization	-0.12	0.11	0.01	0.07	-0.06	0.07
Impulsive Nonconformity	0.14*	0.23	0.01	0.06	0.10	0.08
Individualistic (n = 102)						
Unusual Experiences	0.23*	0.63	0.09	0.12	0.08	0.12
Introvertive Anhedonia	0.12	0.23	<0.001	0.10	0.04	0.11
Cognitive Disorganization	-0.15	0.23	-0.02	0.10	-0.05	0.10
Impulsive Nonconformity	0.01	0.20	-0.06	0.11	0.05	0.11
Collectivistic (n = 161)						
Unusual Experiences	-0.02	0.14	0.01	0.09	-0.04	0.08
Introvertive Anhedonia	0.03	0.13	0.03	0.09	0.003	0.07
Cognitive Disorganization	-0.12	0.17	0.02	0.1	-0.07	0.08
Impulsive Nonconformity	0.22*	0.43	0.06	0.11	0.11	0.10

D2: Anxiety

As seen from Table 4.9, anxiety was not correlated with learned predictiveness even after splitting by culture. Bayesian linear regression was conducted with anxiety as a predictor of the difference scores to the relevant and irrelevant stimuli as well as LPScore for all participants was conducted and there was no significant relationship found even after splitting by culture, largest $F(1, 159) = 1.24$, $p = 0.27$, $R^2 = 0.01$, adjusted $R^2 = 0.001$).

Table 4.9: Summary of correlations from all participants and split by culture of the relationship between anxiety and learned predictiveness in Study 5. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings.

Anxiety	Relevant (r)	Irrelevent (r)	LPScore (r)
All participants (n = 263)	0.03	< 0.001	0.02
Individualistic (n = 102)	0.00	0.05	-0.04
Collectivistic (n = 161)	0.05	-0.05	0.08

D3: The Big 5

When all the participants were analysed together, none of the subscales were significantly correlated with learned predictiveness. It was revealed that in the individualistic group, conscientiousness was positively correlated with the difference scores to the relevant stimuli and agreeableness was negatively correlated with learned predictiveness score. There was also a trend of agreeableness positively correlating with the difference scores to the irrelevant stimuli. None of the subscales were significantly correlated with learned predictiveness in the collectivistic group, see Table 4.10.

Bayesian linear regression was conducted with the Big 5 personality traits as a predictor the difference scores to the relevant and irrelevant stimuli as well as LPScore for all participants was conducted and there was no significant relationship found even after splitting by culture, largest $F(5, 96) = 1.84$, $p = 0.11$, $R^2 = 0.09$, adjusted $R^2 = 0.04$. Although, it should be noted that the Big 5 personality traits predicting the difference scores to the relevant stimuli ratings was approaching significance, $F(5, 96) = 2.17$, $p = 0.06$, $R^2 = 0.10$, adjusted $R^2 = 0.01$.

Table 4.11 shows the summary of coefficients for the Bayesian linear regression. It was revealed that when all the participants were analysed together, extraversion was revealed to be a negative predictor of the difference scores to the irrelevant stimuli and a positive predictor of learned predictiveness score. This means that participants high in extraversion learn less about the irrelevant stimuli and, consequently, also show a greater learned predictiveness effect. However, the BFinclusion supports the null hypothesis and this was further supported by the previous correlation analysis where extraversion was not significantly correlated with the difference scores to the irrelevant stimuli and learned predictiveness score.

For the individualistic group, it was revealed that conscientiousness was a positive predictor of the difference scores to the relevant cues. This means that participants in the individualistic group who are high in conscientiousness learn more about the relevant stimuli. However, this finding is anecdotal. For the collectivistic group, there was also anecdotal evidence of conscientiousness negatively predicting the difference scores to the relevant stimuli in the collectivistic group. Interestingly, it is in contrast with the individualistic group where participants in the collectivistic group high in conscientiousness learn worse about the relevant stimuli.

Table 4.10: Summary of correlations from all participants and split by culture of the relationship between the Big 5 personality traits and learned predictiveness in Study 5. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings. R values italicised with an apostrophe represent p values that approach significance.

Big 5	Relevant (r)	Irrelevent (r)	LPScore (r)
All participants (n = 263)			
Openness	0.03	0.10	-0.05
Conscientiousness	-0.01	0.02	-0.02
Extraversion	0.03	-0.06	0.07
Agreeableness	-0.05	0.04	-0.07
Emotional Stability	0.04	0.05	-0.01
Individualistic (n = 102)			
Openness	0.11	0.20	-0.06
Conscientiousness	0.22*	0.18	0.04
Extraversion	0.05	-0.04	0.06
Agreeableness	-0.11	*0.21'*	-0.22*
Emotional Stability	0.01	0.03	-0.01
Collectivistic (n = 161)			
Openness	-0.01	0.06	-0.05
Conscientiousness	-0.16	-0.04	-0.11
Extraversion	0.01	-0.05	0.05
Agreeableness	-0.03	-0.04	0.01
Emotional Stability	0.05	0.07	-0.01

Table 4.11: Summary of the Big 5 personality traits as coefficients and relevant stimuli, irrelevant stimuli and learned predictiveness score as dependent variables in Study 5. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**Relevant**		**Irrelevant**		**LPScore**	
Big 5	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All participants (n = 263)						
Openness	0.05	0.06	0.14	0.20	-0.10	0.09
Conscientiousness	-0.01	0.05	-0.07	0.08	0.04	0.06
Extraversion	0.05	0.06	-0.16*	0.15	0.16*	0.13
Agreeableness	-0.10	0.06	0.07	0.09	-0.10	0.08
Emotional Stability	0.05	0.06	0.07	0.10	-0.01	0.06
Individualistic (n = 102)						
Openness	0.10	0.50	0.22	0.6	-0.10	0.21
Conscientiousness	0.28*	1.55	0.03	0.32	0.19	0.30
Extraversion	0.04	0.36	-0.22	0.45	0.20	< 0.001
Agreeableness	-0.26	0.91	0.18	0.59	-0.25	0.47
Emotional Stability	-0.01	0.34	-0.01	0.27	-0.02	0.20
Collectivistic (n = 161)						
Openness	0.06	0.20	0.11	0.11	-0.06	0.1
Conscientiousness	-0.26**	0.79	-0.12	0.11	-0.14	0.17
Extraversion	0.004	0.18	-0.09	0.10	0.07	0.10
Agreeableness	0.02	0.19	-0.03	0.09	0.04	0.09
Emotional Stability	0.15	0.36	0.15	0.13	0.03	0.08

D3.i: Further analysis: Simple moderation analysis

To determine if culture moderates the relationship between conscientiousness and the difference score to the relevant stimuli ratings, a simple moderation analysis was conducted, see Figure 4. 39. A simple moderation analysis was chosen because the moderator variable (culture) is dichotomous (i.e., individualistic and collectivistic). As a general rule of thumb, there should be more than 200 participants when running this analysis (Kline, 2011) and there were 263 participants in total.

A significant interaction effect was found between conscientiousness and culture, $\beta = -0.39$, $p = 0.001$. There was no main effect of conscientiousness ($\beta = -0.03$, $p = 0.67$) and culture ($\beta = -1.96$, $p = 0.59$), see Figure 4.17. The moderation analysis revealed that participants in the individualistic group who are high in conscientiousness learned more about the relevant stimuli (estimate = 0.16, z-score = 2.09, p = 0.04) but those in the collectivistic group learned less about the relevant stimuli (estimate = -0.22, z-score = -2.26, p = 0.02), see Figure 4.18 for simple slope plot illustrating this relationship.

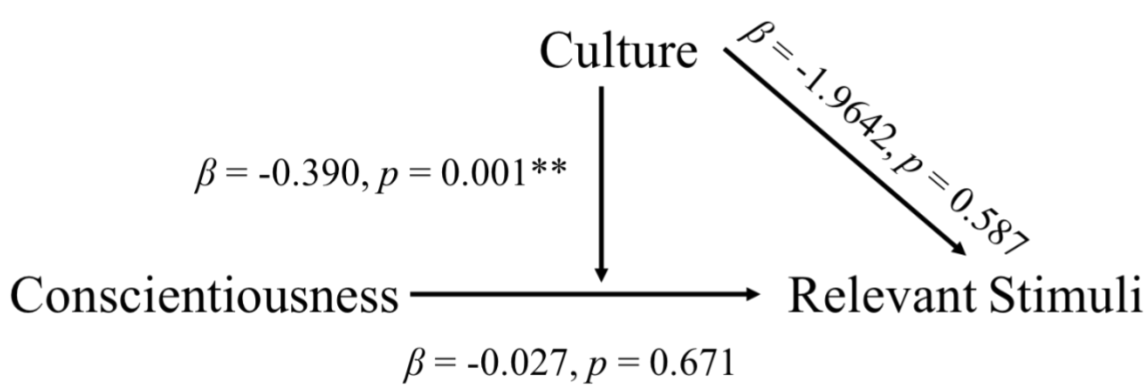


Figure 4.17: Illustration of the relationship between conscientiousness predicting the difference score to the relevant stimuli ratings that is moderated by culture (individualistic and collectivistic) demonstrated in Study 5.

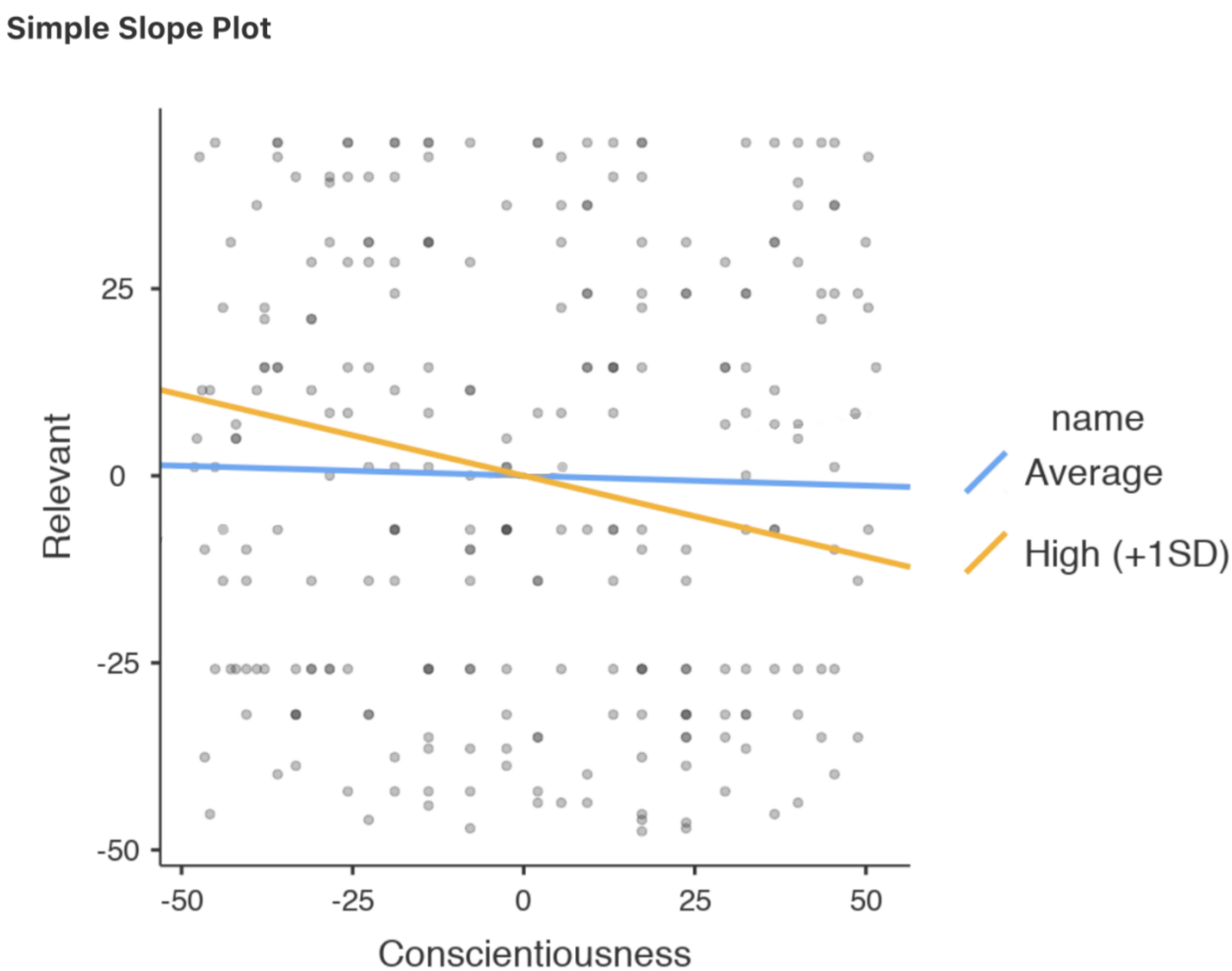


Figure 4.18: Simple slope plot illustrating the relationship between conscientiousness and ratings from relevant stimuli in Study 5. Different coloured lines represent different levels of moderator. Grey line (low - -1SD) refers to the individualistic group, and the orange line (high - +1SD) refers to the collectivistic group.

D4: Summary of findings

The results of this subsection revealed no evidence of anxiety playing a role in learned predictiveness. Regression analyses revealed anecdotal evidence of participants from the individualistic group who were high in unusual experiences positively predicting the difference scores to the relevant stimuli. There was also anecdotal evidence of participants from the collectivistic group high in impulsive nonconformity positively predicting difference scores to the relevant stimuli. As the main effects and interaction effect was not significant in the simple moderation analysis, and thus was not reported, it is difficult to confirm the relationship between unusual experience and relevant stimuli as well as impulsive nonconformity and relevant stimuli, further adding onto the already ambiguous relationship between schizotypy and associative learning.

When split by culture, correlation analyses revealed that there was a positive correlation between conscientiousness and relevant stimuli in the individualistic group. Regression analyses also showed anecdotal evidence of participants from the individualistic group high in conscientiousness learning more about the relevant stimuli and participants from the collectivistic group learning less. This relationship was confirmed using a simple moderation analysis. Participants from the individualistic group also showed a negative correlation between agreeableness and learned predictiveness score. This relationship could not be confirmed as the main effects and interaction effect in the simple moderation analysis was not significant.

4.4: General Discussion

The first aim of this study was to determine if both latent inhibition and learned predictiveness can be generated within the same individual and whether there were any cultural differences in the effects. Next, this study aimed to determine if there is a correlation between the magnitudes of latent inhibition and learned predictiveness and if the magnitudes were impacted by cultural differences. This study also aimed to investigate whether personality traits such as schizotypy, anxiety and the Big 5 predict learning.

4.4.i: Latent Inhibition and Learned Predictiveness

To briefly reiterate the behavioural data, in the letter prediction task, participants' reaction times to the non-preexposed cues were quicker than the preexposed cues, demonstrating a latent inhibition effect. In the food allergist task, participants successfully learned the stimulus-outcome associations in Stage 1 and 2. At test stage, participants provided higher ratings to the relevant stimuli and lower ratings to the irrelevant stimuli, demonstrating a learned predictiveness effect and replicating findings from Study 1 and Le Pelley and McLaren (2003).

When separated into individualistic and collectivistic groups, a latent inhibition effect was still observed. Compared to the individualistic group, the collectivistic group showed a slower reaction time for both cue types. However, the mixed-design ANOVA showed no main effect of culture, suggesting performance in both groups are similar. On the other hand, learned predictiveness was only observed in the individualistic group and not the collectivistic group despite both groups demonstrated moderate learning of the stimulus-outcome relationships in Stage 1 and 2.

Moreover, as seen in Figure 4.11b (Stage 2 of learned predictiveness task), response accuracy for novel food compounds (EF/GH/IJ/KL) were more rapid than the new pairings but with previously seen food items (compounds AV/BV/AW/BW/CX/DX/CY/DY were presented in Stage 1 and in Stage 2, the stimuli were switched to compounds AX/BY/CV/DW), mimicking a latent inhibition effect (see Figure 4.9). However, there was no correlation found between latent inhibition and learned predictiveness in both cultures. This is consistent with the Esber-Haselgrove (2011) hybrid model which provides separate accounts for these two effects. For example, if a stimulus consistently predicts an outcome, its salience will increase (like in a learned predictiveness task) and if the stimulus has already been predicted by another stimulus, its salience will decrease (like in a latent inhibition task). This is also in contrast with the Le Pelley (2004) hybrid model, which predicts a mild correlation between learned predictiveness and latent inhibition. This model involves multiplying the Rescorla-Wagner summed error term with a σ behaving like a Pearce-Hall attention mechanism – predicts latent inhibition; and an α behaving like the Mackintosh attention mechanism – predicts learned predictiveness and to a certain extent, latent inhibition.

4.4.ii: Cultural differences in learning and attention

Both the collectivistic and individualistic groups demonstrated latent inhibition. Despite the non-significant interaction effect, learned predictiveness was only observed in the individualistic, and not in the collectivistic group as revealed in the post-hoc analyses. Previous studies have found that representations of information between individualistic and collectivistic cultures are biased towards more analytical and holistic approaches respectively (Choi, Koo and Choi, 2007; Ji, Peng and Nisbett, 2000; Matsumoto and Yoo, 2006). Therefore, when learning the compounds in the learned predictiveness task, it is possible that participants in the individualistic group learned in a more elemental fashion and participants in the collectivistic group learned more configurally. Therefore, rather than saying that the collectivistic culture experiences difficulty in tuning out irrelevant information, it is possible that they learned about all cues relatively well, irrespective of their predictive validity. At its core, the learned predictiveness effect is about learning how a specific stimulus predicts a specific outcome when said stimulus is presented in a compound. This type of learning is more prominent in individualistic cultures (Ji et al., 2001) and could possibly explain the difference in results. However, Nisbett et al. (2001) also mentioned that it is not that a collectivistic culture is incapable of rule-based learning, but that this culture has developed thinking into more holistic representation of the world (Lehman et al., 2004). This can be supported by Alotaibi et al. (2017) who found that rather than learning the stimuli as separate entities, participants learn configurally.

Further support for these claims could be found in Li, Masuda and Russell (2015) who conducted a decision-making task where they asked participants to imagine that they are trying to rent an apartment. Participants were first randomly split into a time-constrained group and a non-time-constrained group. They were first asked to rate the perceived importance of certain information regarding apartment hunting (suite features, rent, building amenities, size, neighbourhood and transportation links). Their results showed that there were no cultural differences in the amount of information processed. However, when under time constraints, both groups of participants showed faster decision times, less use of information and focussed only on the relevant information. This could be an explanation as to why there were no cultural differences in latent inhibition. Since the stimuli used in the letter prediction task has a predetermined duration of presentation, it can be considered a time-constraint task. Therefore, in order to solve the task (i.e., determine which letter preceded ‘X’), it can be assumed that participants from both cultures would naturally just focus on the relevant information. Moreover, there is only one stimulus being presented in each trial so it would not matter if it is being processed elementally or configurally.

Li et al. (2015) found that under no time restraints, Hong Kong Chinese participants spent less time on decisions compared to European Canadians and processed the information provided more efficiently. The Hong Kong Chinese participants also attended to both important (relevant) and less important (irrelevant) information while the European Canadian participants focussed only on the important (relevant) information throughout. A comparison between Li et al.’s study and the food allergist task used in this study can be drawn. First, the food allergist task was self-paced which is comparable to the non-time-constraint group. Secondly, the way participants from Hong Kong (collectivistic group) attended to both relevant and irrelevant information as compared to the European Canadian participants who only attended to the relevant information is consistent with the results of this current study where participants in the individualistic group exhibited higher ratings for relevant than irrelevant stimuli, and participants from the collectivistic group provided similar ratings for both relevant and irrelevant stimuli. Moreover, the between subjects t-test conducted for each stimulus suggests that there were no differences in learning, congruent with Li et al. who found that participants used the same amount of information to make decisions.

Another example of different attention allocation towards relevant and irrelevant stimuli can be found in a study by Li, Masuda, Hamamura and Ishii (2018) who created a fort game where they wanted to see if the enemy is going to attack a fort, how would their participants allocate their resources (soldiers) in protecting the fort. They found that both Hong Kong Chinese and European Canadian participants stationed most of their resources at the focal attack point, but Hong Kong Chinese participants tended to disperse their troops to various locations around the fort. They concluded that analytical thinkers (Canadian participants) would make decisions based on the most critical information while holistic thinkers (Chinese participants) would make decisions based on critical and non-critical information. Hence, Li et al.'s study could be interpreted as a literal representation of attention allocation in individualistic and collectivistic individuals.

4.4.iii: Individual differences in latent inhibition

Analyses from the polychoric correlation and Bayesian linear regression revealed that introvertive anhedonia positively predicts learning about PE cues and the overall latent inhibition effect. This suggests that individuals who are high in introvertive anhedonia respond slower towards PE cues and show a greater latent inhibition effect. Although this is consistent with other studies that have shown enhancements in latent inhibition in participants high in schizotypy (Granger et al. 2016), the specifics are rather different, as previous findings have found an association with unusual experiences, but Cohen et al. (2004) found an enhancement in latent inhibition with schizophrenia patients showing negative symptoms.

The effect of introvertive anhedonia was abolished in the individualistic group but remained in the collectivistic group; indicating only participants from the collectivistic group who are high in introvertive anhedonia show enhanced latent inhibition. This is somewhat inconsistent with Kraus et al. (2016) who tested Singaporean nationals (according to the Hofstede database, Singapore is collectivistic) and found that latent inhibition is abolished in participants who are at an ultra-high risk in schizophrenia.

Moreover, impulsive nonconformity has been shown to positively predict overall latent inhibition reflecting an enhanced effect of latent inhibition. Gray et al. (2002) found an effect of impulsive nonconformity but specific to a quicker learning of the preexposed cues resulting in reduced latent inhibition. Granger et al. (2016) also observed an effect of impulsive nonconformity but in the preexposed and non-preexposed cues. Their results indicate that regardless of familiar or novel cues, reaction times were quicker, and this makes intuitive sense, where people who are impulsive would respond to cues relatively quicker. However, it should be noted that the Bayes factor inclusion does not support either the null or alternative hypothesis and hence, these results could only be treated as anecdotal.

Additionally, the effect of impulsive nonconformity positively predicting latent inhibition score persisted in the individualistic group but was abolished in the collectivistic group. A closer look into the individualistic group's Bayes factor inclusion is close to 3; and therefore, a simple moderation analysis was conducted which revealed that individuals high in impulsive nonconformity show enhanced latent inhibition only in the individualistic group. The results of this study also revealed emotional stability as a positive predictor of learning about the preexposed cue, suggesting that those who are emotionally stable or low in neuroticism showed disrupted learning of the preexposed cues. Individuals who are high in trait anxiety are low in emotional stability (Goldberg, 1992) and high in neuroticism (Costa and McCrae, 1992). Trait anxiety has been associated with an attenuation of latent inhibition (Braunstein-Bercovitz, 2000), which therefore accounts for emotionally stable participants showing latent inhibition.

4.4.iv: Individual differences in learned predictiveness

The Bayesian linear regression showed extraversion as a negative predictor of learning about irrelevant stimuli and a positive predictor of learned predictiveness score overall. It also showed impulsive nonconformity as a positive predictor of relevant stimuli. However, the Bayes factor inclusion supports the null hypothesis, which suggests no real effect of extraversion and impulsive nonconformity on learned predictiveness.

Regression analyses revealed that the unusual experiences trait was a positive predictor of learning about the relevant stimuli but only for the individualistic culture. This suggests that participants from the individualistic group who are high in unusual experiences learn *more* about the relevant stimuli. This is in contrast with Le Pelley et al. (2010) who tested Cardiff University students [6] and found that participants high in unusual experiences showed a reduction in learned predictiveness.

It was also revealed that impulsive nonconformity was a positive predictor for learning about relevant stimuli but only for collectivistic group. This suggests that participants from the collectivistic group who are high in impulsive nonconformity learn more about the relevant stimuli. This could reflect that individuals that are more impulsive learn the associations between stimuli and outcome better. Individuals who are impulsive have been shown to make decisions that result in quicker albeit smaller gains (Grecucci, Giorgetta, Rattin, Guerreschi, Sanfey and Bonini, 2014). It could be proposed that the immediate feedback given on every trial of Stage 1 and 2 of the food allergist tasks encouraged better learning of the relevant stimuli by participants high in impulsive nonconformity.

Footnote 6: While Wales is not listed as a country in the Hofstede database, it is a United Kingdom nation, which is considered an individualistic nation.

The results obtained from the correlation analyses revealed a trend of conscientiousness having a positive relationship with relevant stimuli and agreeableness having a negative relationship with learned predictiveness score. The effect of conscientiousness was confirmed to be a predictor of relevant stimuli by the regression analyses. Results from the simple moderation analysis revealed that conscientiousness itself does not predict relevant stimuli ratings and there was no group differences in learning about the relevant stimuli, the significant interaction effect and slope analysis indicates that participants from the *individualistic* culture who are *high in conscientiousness learn more* about the relevant stimuli while participants from the *collectivistic* who are *high in conscientiousness learn less* about the relevant cues.

Thompson (2008) defined a conscientiousness individual as someone who is organised, systematic and efficient. It can then be inferred that participants high in conscientiousness would attempt to pay attention to the stimuli that best predicts the outcomes. In combination with the different thinking styles of the individualistic and collectivistic group, it is possible that participants from the individualistic group would learn more about the relevant stimuli because of its previous good predictive history. For the collectivistic group, participants high in conscientiousness would pay attention to the relevant stimuli as much as to the irrelevant stimuli because their tendency to learn holistically would result in them splitting their attention between the two types of stimuli.

4.4.v: Conclusions

In conclusion, latent inhibition was found in all participants. While there was no significant main effect of culture and interaction effect between culture and relevance of stimuli, as one of the aims of this study was to determine if there was a cultural difference in learned predictiveness, the paired samples t-test revealed that participants rated the relevant stimuli higher than the irrelevant stimuli, but this was not demonstrated in the collectivistic participants. There was no correlation between latent inhibition and learned predictiveness. The nature of this study is exploratory and hence, further testing should be conducted to determine if this study's findings can be replicated. Importantly, the failure in demonstrating learned predictiveness in the collectivistic culture should be further investigated to determine if a difference in information processing is the cause.

Participants in the individualistic group who are high in impulsive nonconformity were found to demonstrate an enhanced latent inhibition effect. Therefore, this design should be replicated to determine if the effect of impulsive nonconformity is truly present or is just an artefact of this experiment.

Culture was found to moderate how conscientiousness predicts the learning of relevant stimuli in the learned predictiveness task; participants high in conscientiousness in the individualistic group showed more learning while participants in the collectivistic group showed less learning. As this study is the first to investigate whether the Big 5 personality traits as well as culture play a role in predicting learning, a future study where the design is replicated but a more sensitive measure of individualism and collectivism should be conducted.

Chapter 5:

Study 6: Relationship between Personality Traits and Cultural Orientation in Latent Inhibition - An Online Replication

5.1: Introduction

To recap, an effect of stimulus familiarity on the rate of learning was observed in Study 5 and was found in both individualistic and collectivistic groups – latent inhibition. Thus, the first aim of this study was to replicate these findings as there have been no previous studies that have explicitly compared the magnitude of latent inhibition in participants from individualistic and collectivistic cultures.

The findings also revealed that participants who scored high on the impulsive nonconformity sub-dimension of the O-LIFE demonstrated a greater latent inhibition effect. This is inconsistent with the results of Granger et al. (2016) who employed the same task as employed in Study 5 and who showed an enhancement of latent inhibition but in those who score high on unusual experiences. Furthermore, the simple moderation analysis conducted demonstrated that the predicting effects of impulsive nonconformity on the enhancement of latent inhibition was only found in the individualistic group. Therefore, this experiment aimed to replicate the procedure in Study 5 to further investigate how schizotypy affects the enhancement of latent inhibition and determine that the previous results found were reliable.

Due to the COVID-19 global pandemic, data collection had to be conducted online. This in turn was beneficial because it allowed for data recruitment from various countries, permitting a broader examination of the impact of cultural background as a potential predicting variable. Consequently, this study also aimed to determine if similar latent inhibition effects could still be observed in an online-based environment and if the effects of impulsive nonconformity persisted in this context. To date, the vast majority of studies that have investigated latent inhibition, like much of experimental psychology, have been conducted with in-person testing procedures. It thus remains unclear if this phenomenon will replicate under less tightly controlled circumstances. Moreover, and in keeping with study 5, this study was also interested in exploring whether trait anxiety and the Big 5 predict latent inhibition in an online study. It was anticipated that an online letter prediction task would still generate latent inhibition and there would be no differences between individualistic and collectivistic culture as in Study 5. Secondly, to the extent that the results of study 5 are reliable, it was predicted that latent inhibition can be influenced by personality traits such as unusual experiences (Evans et al., 2007; Gray et al., 2002), trait anxiety (Braunstein-Bercovitz, 2000) and openness (Peterson et al., 2000, 2002). Additionally, based on the results of Study 5, an effect of impulsive nonconformity positively playing a role in enhanced latent inhibition by participants from the individualistic group was also predicted.

5.2: Methods

5.2.i: Participants

145 participants were recruited from the University of Nottingham UK, the University of Nottingham Malaysia Campus and Prolific (online recruitment platform). There were 72 males and 73 females. The age of the participants ranged from 18 to 30 years old, (M = 23.13, SD = 3.40). Participants from the universities were recruited through the school's Research Participation Scheme, recruitment posters and word of mouth. In the Malaysian campus, first year psychology undergraduates were compensated with course credit and the rest of the participants were compensated with Ringgit Malaysia 10. In the UK campus, first year psychology undergraduates were compensated with course credit and participants from Prolific were compensated with £3. Prolific was chosen because it is an online studies recruitment platform created specifically for researchers and participants are informed beforehand that their data would be used for research

purposes. Additionally, Prolific has clear guidelines about the rights, obligations and compensation of participation for both the researcher and participants. This study also adhered to the ethical guidelines of the School of Psychology in the Malaysian Campus.

5.2.ii: Procedure

Participants completed the experiment on their own personal devices such as their laptops or desktop computers as this experiment is not compatible with smartphones or tablets. They were advised to run the task on Google Chrome. Participants were provided a Qualtrics link. If participants were recruited from Prolific, they were automatically redirected to Qualtrics once they clicked on the study from the Prolific page. From Qualtrics, they were asked to click on a link that would direct them to Pavlovia, the online studies platform of PsychoPy, where they would complete the letter prediction task (as described in Study 5, see Chapter 4.2.v.a). In the preexposure stage, participants were presented with a series of letters on the computer screen and were tasked to say them out loud. After a short break, participants were presented with a series of letters again but this time, they were tasked to press the spacebar when the letter "X" appears on the screen or when they thought the letter "X" is going to appear. At the end of the task, they were asked to return to the Qualtrics page where they were asked to complete the 3 questionnaires (OLIFE, STICSA and the Big 5). The presentation order of these questionnaires was varied using Qualtrics' randomization function. After completing all the questionnaires, they were redirected back to the Prolific website to confirm that they have completed the experiment.

5.3: Results

This section will first describe on what basis participants will be removed from analysis. It will then describe how participants were separated into individualistic and collectivistic groups. The treatment of behavioural and psychometric data was the same as in Chapter 4 (see Chapter 4: Results/Data treatment). Next, the analysis of the latent inhibition behavioural data will be discussed. The behavioural data will also be split by culture to analyse. This is followed by a comparison of the lab-based (Chapter 4) and the current online data to determine if there are differences when conducting the task in two different types of environment. After these analyses, the psychometric data will be analysed. Participants will be split into individualistic and collectivistic groups again to determine if there are cultural differences in personality traits predicting latent inhibition.

To determine if there were any correlations between personality traits and learning, a polychoric correlations rather than a Pearson/Spearman correlation were again conducted as they are the most consistent and robust estimator for ordinal variables (Holgado-Tello et al., 2009). A parallel approach of using both frequentist and Bayesian linear regressions was again used because Bayesian analysis can discern whether a $p > 0.05$ is the result of a true null effect or an insensitivity of the data to reveal an effect.

Part A: Data treatment

14 participants were eliminated due to not completing the behavioural task or for responding to fewer than 10 trials with either the preexposed or non-preexposed stimuli. The final n was 131. These participants also completed all three questionnaires and passed all the awareness checks within the questionnaires.

Participants were grouped by nationality as in Study 5. There was n = 80 in the individualistic group, and n = 51 in the collectivistic group. The individualist group consists of participants that reported their nationality as American, Belgian, British, Canadian, Dutch, English, Estonian, Finnish, French, Hungarian, Italian, Latvian, Polish, Scottish and the collectivistic group consisted of participants who reported their nationality as Brazilian, Chinese, Filipino, Greek, Indian, Indonesian, Malaysia, Mexican, Portuguese, Slovenian, Spanish, Turkish, Ugandan, Vietnamese.

The raw data were downloaded from Gitlab, an online repository where the data collected were saved and stored. A "latent inhibition score" was calculated by subtracting reaction times to the non-pre-exposed cue from reaction times to the pre-exposed as in Study 5.

A reliability analysis was conducted for the OLIFE, STICSA and Big 5 questionnaires. The values are as follows: 1) OLIFE ([unusual experiences, introvertive anhedonia, cognitive disorganization, impulsive nonconformity], McDonald's omega = 0.85, 0.85, 0.87, 0.77 respectively); 2) STICSA (McDonald's omega = 0.90); 3) Big 5 ([openness, conscientiousness, extraversion, agreeableness and emotional stability], McDonald's omega = 0.79, 0.80, 0.84, 0.81, 0.75 respectively). According to Feißt et al. (2019), a score of more than 0.80 is considered to have good internal reliability.

Part B1: Analysis of behavioural data

Participants' mean reaction times can range from 0 to 2050 ms. If participants' reaction times are less than 1050 ms, they anticipated X. If it is between 1050-2050 ms, participants are responding to X. As seen from Figure 5.1, the reaction times for both the PE and the NPE cues declined as training continued, and that also, reaction times for the PE cue was higher than the

NPE cue, suggesting a latent inhibition effect. This was confirmed with a 2(cue) x 20 (trial) repeated measures ANOVA of individual reaction times which revealed a main effect of trial, $F(7.32, 424.42) = 16.07$, $p < 0.001$, $\eta^2_p = 0.22$, a main effect of cue, $F(1, 58) = 15.36$, $p < 0.001$, $\eta^2_p = 0.21$ and a significant interaction between cue and trial, $F(12.08, 700.53) = 1.80$, $p = 0.04$, $\eta^2_p = 0.03$.Post-hoc analyses revealed an effect of trials for both cues, largest $F(9.53, 686.33) = 15.64$, $p < 0.001$, $\eta^2_p = 0.18$, suggesting an improvement in reaction time as training progressed. Further analysis with a simple main effects analysis revealed that the reaction time of the preexposed cue was significantly slower than non-preexposed cue on trials 3, 8 to 10 and 14 to 20 ($p < 0.05$).

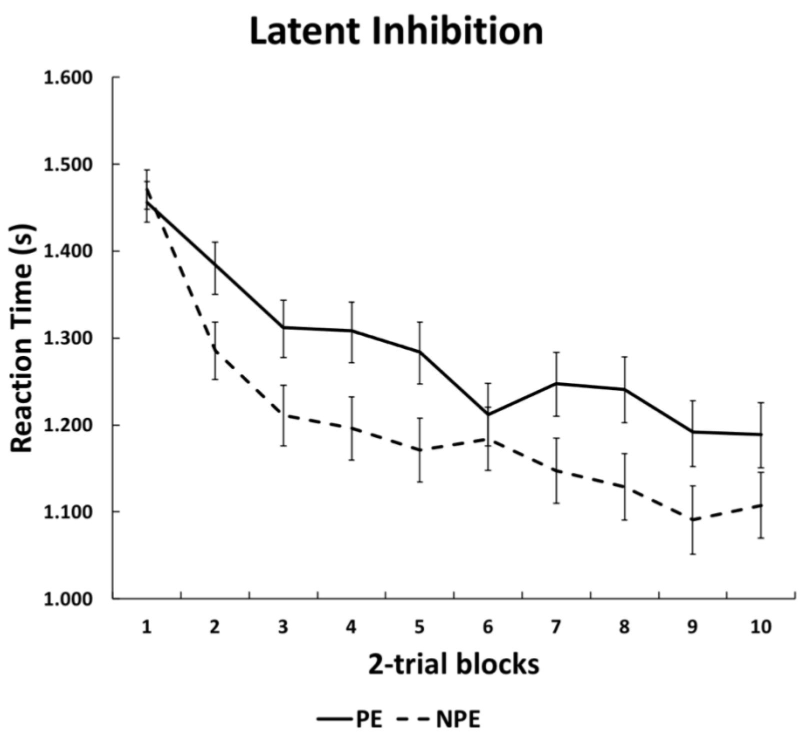


Figure 5.1: Mean reaction time to the PE and NPE across 10 2-trial blocks in Study 6. Error bars represent standard error of mean.

B2: Cultural differences in latent inhibition

It can be seen in Figure 5.2 that both the individualistic and collectivistic groups reacted slower to the pre-exposed cue than the non-pre-exposed cue. A 2 (culture) x 2 (cue) x 20 (trial) mixed-design ANOVA was conducted to determine if the two cultures differed in the learning of the different types of cues across the trials. There was a main effect of cue, $F(1, 57) = 16.74$, $p < 0.001$, $\eta^2_p = 0.21$, and main effect of trial, $F(7.24, 412.65) = 15.89$, $p < 0.001$, $\eta^2_p = 0.23$, but no main effect of culture, $F(1, 57) = 0.04$, $p = 0.85$, $\eta^2_p = 0.001$. There was a significant interaction between cues and trials, $F(12.03, 685.62) = 2.00$, $p = 0.02$, $\eta^2_p = 0.03$. All the other two-way interactions and the three-way interaction were not significant, largest $F(1, 57) = 1.66$, $p = 0.20$, $\eta^2_p = 0.03$.

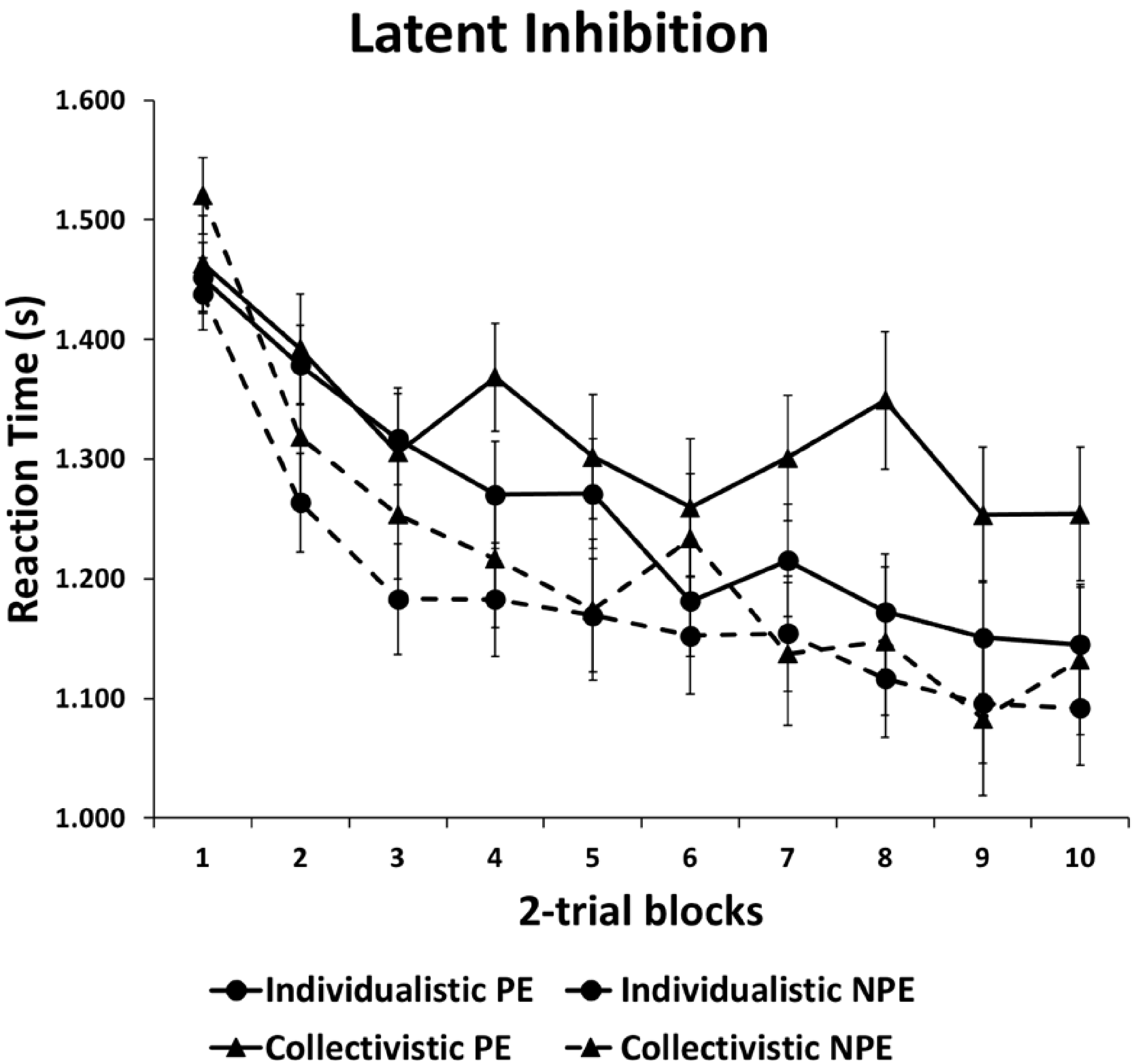


Figure 5.2: Mean reaction time to the PE and NPE across 10 2-trial blocks separated by culture in Study 6. Error bars represent standard error of mean.

B3: Differences between lab-based and online experiments

To determine if there was a difference in reaction time between conducting a lab-based and online latent inhibition tasks, a Bayesian between-subjects t-test was conducted, (PE = $t(392) = 1.27$, $p = 0.21$, $BF_{10} = 0.26$, $d = 0.14$; NPE = $t(392) = 1.76$, $p = 0.08$, $BF_{10} = 0.52$, $d = 0.19$; latent inhibition score = $t(392) = -0.77$, $p = 0.44$, $BF_{10} = 0.16$, $d = 0.08$), suggesting no difference between responses given in the lab-based and online tasks, Table 5.1. According to Dienes (2014), the Bayes factor for PE and latent inhibition score suggests that there was weak evidence of a difference between conducting the latent inhibition task in a lab or online, while NPE showed anecdotal evidence.

Table 5.1: Means and standard error of mean of pre-exposed cues, nonpre-exposed cues and latent inhibition score, n (total) = 394 in Study 6.

	N	Mean	SE
PE cues			
online	263	1.32	0.02
offline	131	1.28	0.02
NPE cues			
online	263	1.25	0.02
offline	131	1.19	0.03
LIScore			
online	263	0.07	0.01
offline	131	0.08	0.02

B4: Summary of findings

Initial analysis of the data suggests that participants exhibited latent inhibition. Upon further analysis, both individualistic and collectivistic group showed latent inhibition. There was also no difference between the effect of latent inhibition between the lab-based and the online experiments.

Part C: Effects of personality traits

To investigate the relationship between the schizotypy, anxiety and Big 5 are associated with latent inhibition, polychoric correlations was first conducted. Next, a frequentist and Bayesian lines regression were conducted with the personality traits and subscales as the predictors of response times to the preexposed cues, non-preexposed cues and latent inhibition score.

C1: Schizotypy

Correlation analyses showed that none of the OLIFE subscales correlated with the reaction times to the preexposed, non-preexposed cues and latent inhibition score. This is also the same when participants were split into individualistic and collectivistic groups, see Table 5.2.

To determine whether there is a relationship between schizotypy and latent inhibition, a Bayesian linear regression was conducted. The OLIFE subscales were entered as a predictor of the reaction times to the PE, NPE cues and latent inhibition score (LIScore), and no significant relationship was found for all participants, as well as when split by culture, largest $F(4, 75) = 1.07$, $p = 0.38$, $R^2 = 0.05$, adjusted $R^2 = 0.003$.

Table 5.2: Summary of correlations from all participants and split by culture of the relationship between the OLIFE subscales and latent inhibition in Study 6. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

OLIFE	PE (r)	NPE (r)	LIScore (r)
All participants (n = 131)			
Unusual Experiences	0.06	0.11	-0.08
Introvertive Anhedonia	-0.12	-0.04	-0.08
Cognitive Disorganization	0.05	0.07	-0.04
Impulsive Nonconformity	-0.01	0.01	-0.02
Individualistic (n = 80)			
Unusual Experiences	0.07	0.12	-0.08
Introvertive Anhedonia	-0.11	-0.02	-0.10
Cognitive Disorganization	0.11	0.14	-0.06
Impulsive Nonconformity	-0.03	-0.04	0.02
Collectivistic (n = 51)			
Unusual Experiences	0.06	0.10	-0.06
Introvertive Anhedonia	-0.15	-0.08	-0.07
Cognitive Disorganization	-0.03	-0.02	0.00
Impulsive Nonconformity	0.03	0.09	-0.09

C2: Anxiety

As seen from Table 5.3, anxiety was not correlated with latent inhibition even after splitting by culture. Bayesian linear regression was conducted with anxiety as a predictor for the reaction times to the PE, NPE cues and LIScore for all participants as well as split by culture, and there was no significant relationship found, largest $F(1, 78) = 0.62$, $p = 0.43$, $R^2 = 0.01$, adjusted $R^2 = -0.01$.

Table 5.3: Summary of correlations from all participants and split by culture of the relationship between anxiety and latent inhibition. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Anxiety	PE (r)	NPE (r)	LIScore (r)
All participants (n = 131)	0.03	0.05	-0.04
Individualistic (n = 80)	0.08	0.09	-0.02
Collectivistic (n = 51)	-0.03	0.01	-0.04

C3: The Big 5

As seen from Table 5.4, the Big 5 personality traits were not correlated with latent inhibition even after splitting by culture. Bayesian linear regression was conducted with the Big 5 personality traits as a predictor for the reaction times to the PE, NPE cues and LIScore for all participants as well as split by culture, and there was no significant relationship found, largest $F(5, 45) = 1.48$, $p = 0.22$, $R^2 = 0.14$, adjusted $R^2 = 0.05$, see Table 5.5 for summary of coefficients.

When all the participants were analysed together, it was revealed that openness was a positive predictor of latent inhibition score, indicating that participants high in openness showed enhanced latent inhibition. However, the evidence for this finding was anecdotal as denoted by the $BF_{inclusion}$ value. It was also revealed that conscientiousness was a positive predictor of the reaction times to the nonpre-exposed cues, reflecting slower learning of nonpre-exposed cues for participants high in conscientiousness. However, the $BF_{inclusion}$ value supports the null hypothesis of this finding.

For participants from the individualistic group, it was revealed that conscientiousness was a positive predictor of the reaction times to the nonpre-exposed cues and a negative predictor of latent inhibition score. This means that participants from the individualistic group who are high in conscientiousness show slower learning of non-preexposed cues and a diminished latent inhibition effect. However, the $BF_{inclusion}$ value indicates that these findings are anecdotal. For participants from the collectivistic group, it was revealed that openness was a positive predictor of latent inhibition score, which means that participants in the collectivistic group who are high in openness show enhanced latent inhibition. Again, however, the $BF_{inclusion}$ value indicates that this finding to be anecdotal.

C4: Summary of findings

No evidence of schizotypy and anxiety in playing a role in latent inhibition was found. The absence of a schizotypy effect is inconsistent with findings from Study 5 where impulsive nonconformity was positively predicting a greater magnitude of latent inhibition. However, anxiety continues to show no evidence of predicting latent inhibition as in Study 5. There was anecdotal evidence of participants high in conscientiousness from the individualistic group learning about the non-preexposed slower and exhibiting a smaller magnitude of latent inhibition. This was not previously demonstrated in Study 5. There was also anecdotal evidence of participants high in openness from the collectivistic group exhibiting greater magnitudes of latent inhibition. This was inconsistent with previous literature where openness has been shown to predict reduced latent inhibition (Peterson et al., 2000), see general discussion for further details.

Table 5.4: Summary of correlations from all participants and split by culture of the relationship between the Big 5 personality traits and latent inhibition in Study 6. *Note*: $p < 0.05$*. The LIScore was calculated from subtracting the non-preexposed (NPE) cues reaction times from the preexposed (PE) cues reaction times.

Big 5	PE (r)	NPE (r)	LIScore (r)
All participants (n = 131)			
Openness	0.10	-0.03	0.16
Conscientiousness	0.14	0.14	-0.03
Extraversion	0.04	0.02	0.03
Agreeableness	0.09	0.00	0.09
Emotional Stability	0.08	0.02	0.06
Individualistic (n = 80)			
Openness	0.06	0.00	0.08
Conscientiousness	0.12	0.20	-0.14
Extraversion	-0.08	-0.09	0.02
Agreeableness	0.10	0.00	0.12
Emotional Stability	0.06	0.04	0.02
Collectivistic (n = 51)			
Openness	0.21	-0.06	0.31
Conscientiousness	0.20	0.03	0.18
Extraversion	0.28	0.19	0.06
Agreeableness	0.07	0.02	0.06
Emotional Stability	0.13	0.00	0.14

Table 5.5: Summary of the Big 5 personality traits as coefficients and pre-exposed cues, nonpre-exposed cues and latent inhibition score as dependent variables in Study 6. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**PE**		**NPE**		**LIScore**	
Big 5	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All participants (n = 131)						
Openness	0.06	0.13	-0.12	0.14	0.23*	0.43
Conscientiousness	0.11	0.19	0.24*	0.28	-0.19	0.22
Extraversion	-0.04	0.10	0.01	0.11	-0.07	0.15
Agreeableness	-0.01	0.11	-0.07	0.12	0.08	0.18
Emotional Stability	0.05	0.11	-0.01	0.11	0.08	0.17
Individualistic (n = 80)						
Openness	0.03	0.14	-0.08	0.23	0.14	0.27
Conscientiousness	0.10	0.18	0.32*	0.60	-0.32*	0.44
Extraversion	-0.19	0.19	-0.14	0.29	-0.04	0.21
Agreeableness	0.11	0.17	-0.08	0.23	0.23	0.36
Emotional Stability	0.04	0.14	0.03	0.21	0.003	0.21
Collectivistic (n = 51)						
Openness	0.11	0.32	-0.2	0.24	0.39*	1.07
Conscientiousness	0.14	0.31	-0.01	0.20	0.16	0.37
Extraversion	0.24	0.53	0.33	0.35	-0.16	0.35
Agreeableness	-0.17	0.26	-0.01	0.2	-0.18	0.35
Emotional Stability	-0.01	0.25	-0.07	0.2	0.08	0.33

5.4: General Discussion

This study aimed to establish whether latent inhibition effects can be found online. Next, it aimed to replicate the effect of impulsive nonconformity on the magnitude of latent inhibition and to determine if this relationship is specific to the preexposed or non-preexposed cue. This study also aimed to determine if trait anxiety and the Big 5 personality traits play a role in latent inhibition.

First, when analysing data from all participants, it was revealed that the reaction time for pre-exposed cues were slower than nonpre-exposed cues, demonstrating a latent inhibition effect, providing further support to the hybrid models as well as traditional models such as the Pearce-Hall (1980) model. When participants were separated by individualist and collectivistic culture, latent inhibition was still evident in both groups, replicating findings in Chapter 4. This demonstrates that the letter prediction task can be used in an online setting, further validating its reliability to be used in experiments in different environments. Due to the Covid-19 global pandemic, many nations worldwide have been placed into lockdown, which resulted in many in-person testing to be halted, and consequently, researchers had to migrate and adapt to online testing methods. Online data collection is usually conducted through websites such Amazon's MTurk or Prolific which have been shown to be valid participant recruitment platforms (Crump, McDonell and Gureckis, 2013; Palan and Schitter, 2018). In a series of experimental psychology tasks including the Stroop task (Stroop, 1935), the Simon task (Simon, 1969) and the Posner cueing task (Posner, 1980), Crump et al. (2013) showed that online testing was able to replicate these common psychology tasks. Moreover, Peyton, Huber and Coppock (2020) observed that the generality of online experiments did not suffer due to the pandemic.

The results of this study showed no evidence of trait anxiety predicting latent inhibition which is consistent with results from Study 5. A similar version of the letter prediction task used in this study was employed by Granger et al. (2021) who also ran the study online using the CANTAB Connect platform-hosting site. In their study, they induced state anxiety by administering their participants with 7.5% carbon dioxide gas and a second group of participants was administered medical air as the control group. Their results found that the control group demonstrated a latent inhibition effect while the effect was abolished in the high anxiety group. They also observed that the absence of latent inhibition was due to an impaired learning of the non-preexposed cue. However, the current study did not measure state anxiety and therefore, it was not possible to make any comparisons. Although in hindsight, considering the fact that this experiment was conducted during the height of the pandemic, the general levels of state anxiety experienced by participants might be relatively higher than any other period of time and similar findings to Granger et al. could have been found.

The effect of impulsive nonconformity positively predicting enhanced latent inhibition that was observed in Study 5 was not replicated. Instead, analyses from the regressions conducted found anecdotal evidence supporting openness as a positive predictor of latent inhibition score, suggesting that participants high in openness experienced enhanced latent inhibition and inconsistent with Study 5's findings. Upon further analysis, it was found that this effect is specific to the collectivistic group. This is inconsistent with Peterson et al. (2000; 2002) who conducted an auditory latent inhibition task and observed that participants high in openness show a reduced latent inhibition effect. While Peterson et al. did not measure the cultural orientation of their participants, based on the results of the current study and of Study 5, there is no basis of a cultural difference in latent inhibition as indicated by the non-significant main effect of culture in the analysis conducted.

Asai et al. (2015) found a positive relationship between openness and unusual experiences [7] and unusual experiences have been implicated with reduced latent inhibition (Granger and Young, 2012; Gray et al., 2002). However, there has also been evidence of enhanced latent inhibition in participants high in unusual experiences (Granger et al., 2016) and they found that the enhancement of latent inhibition was due to an increased reaction times for the pre-exposed. Considering the relationship between openness and unusual experiences, the results of this current study is somewhat consistent with Granger et al. although there was no evidence from this current study that the enhanced latent inhibition effect was cue specific.

The results from the regressions of the individualistic group found anecdotal evidence of conscientiousness positively predicting reaction times to nonpre-exposed cues and a negatively predicting latent inhibition score. In other words, participants high in conscientiousness have slower reaction times towards nonpre-exposed cues and a weaker latent inhibition effect. Individuals high in conscientiousness have been argued to be respectful of protocol, are thorough in their actions and have better control of their actions (Rolland, 2002). The target letter 'X' occasionally follows filler letters, which may cause the participants to think that there are more predictive cues present other than the predetermined pre-exposed and nonpre-exposed cues. Therefore, participants high in conscientiousness may be hesitant to respond to cues without being certain that they are the correct cues, resulting in the increased reaction times.

Footnote 7: See Appendix F for path analyses conducted to show the relationship between the Big 5 personality traits and schizotypy traits as defined by the OLIFE.

Moreover, *stability*, a metatrait which consists of conscientiousness, agreeableness and low neuroticism (DeYoung, 2015) has been associated with a tendency to resist impulsive behaviours (Hirsch, Peterson and DeYoung, 2009). This provides further basis that conscientiousness can influence the response times. However, it is unclear why this effect is specific to the non-preexposed cue and therefore, requires further investigation.

This study suffers from two limitations. The first was that data collection was interrupted and therefore, had to be stopped before it reached the minimum number of participants of 200 for a moderation analysis (Kline, 2011). Therefore, it was not possible to determine whether culture plays a role in the relationship of: i) openness predicting latent inhibition; and ii) conscientiousness predicting reaction times of the non-preexposed cues. The second limitation was that participants were divided into individualistic and collectivistic groups via their nationalities and it has been shown that various external factors can influence individualism and collectivism within a person, and this will be discussed in detail in the following chapter. Perhaps the reason why the results observed from the regression analyses were anecdotal was because participants were not divided with a more sensitive measure of cultural orientation. Therefore, future studies should consider using a more accurate tool to measure trait individualism and collectivism within an individual to replicate the effects of conscientiousness and openness on latent inhibition.

In conclusion, the letter prediction task was reliable in generating latent inhibition in an online remote-testing scenario. One of the aims of this study is to demonstrate that schizotypy predicts latent inhibition but the effects of impulsive nonconformity predicting latent inhibition found in Study 5 was not replicated, which regrettably does not help clarify the inconsistent findings found in the literature. There was also no evidence of trait anxiety predicting latent inhibition. There was anecdotal evidence of participants from the individualistic group high in conscientiousness to demonstrate a reduced latent inhibition effect and this was due to slower responding towards the non-preexposed cues. There was also anecdotal evidence of participants from the collectivistic group high in openness to show enhanced latent inhibition. Limitations of this study as well as potential future directions have been discussed.

Chapter 6:

Study 7: The Relationship between Personality Traits and Cultural Orientation in Learned Predictiveness - An Online Replication

6.1: Introduction

To recap, Study 5 demonstrated that, across all participants, a bias was acquired to learn more about stimuli that had a history of being predictive of a trial outcome than a stimulus that was task irrelevant: learned predictiveness. Furthermore, when participants were separated into individualistic and collectivistic groups based on their nationalities according to the Hofstede database, despite moderate learning of the stimulus-outcome association from both groups and a lack of significant main effect of culture and interaction effect between culture and relevance of stimuli, a learned predictiveness effect in the individualistic group was revealed through the post-hoc analysis. However, the lack of a learned predictiveness effect in the collectivistic culture did not appear to be a consequence of a more general learning disruption, as training in Stage 1 and 2 proceeded equivalently in both groups. The results also revealed that culture played a moderating role in the relationship between conscientiousness and relevant stimuli. The individualistic group showed that participants who are high in conscientiousness provided higher ratings for the relevant stimuli while participants in the collectivistic group who are high in conscientiousness provided lower ratings for the relevant stimuli. It could then be hypothesized that conscientiousness plays a moderating role in determining how much attention can be allocated when learning associations between stimuli and outcomes.

Due to the difference in thinking patterns (i.e., individualistic cultures think more elementally while collectivistic cultures think more configurally), it can be expected that participants from the individualistic culture would be able to pay more attention to relevant stimuli while participants from the collectivistic culture would be able to attend more to relevant stimuli too, but some of the attention would also be shared among the irrelevant stimuli.

This is consistent with (Li et al., 2015) who found that when training is performed under no time constraints, participants from a collectivistic culture took into account both relevant and irrelevant information before making decisions compared to participants from an individualistic culture, who only process relevant information. Moreover, (Li et al., 2018) found that participants from individualistic cultures allocate resources more abundantly in focal points while those from collectivistic cultures would spread some of their resources to the surrounding visual field.

In the previous two studies, participants were sorted into individualistic and collectivistic groups using Hofstede's measurement of cultural orientation, which is based on nationalities. However, Sharma (2010) has argued that people from individualistic countries would show trait collectivism and vice versa. This is consistent with Oyserman, Coon and Kemmelmeier (2002) who found that individuals from an individualistic culture would not always have a higher score on measures of individualism and lower scores of collectivism. These variations could be due to regional differences within countries (Kitayama, Ishii, Imada, Takemura and Ramaswamy, 2006; Vandello and Cohen, 1999; for review, see Cohen, 2009), socio-economic status (for review, see Kitayama and Uskul, 2011) and globalization of mass media (Hamdan and Ismail, 2019; Maisuwong, 2012).

Vandello and Cohen (1999) observed that levels of individualism and collectivism vary across different parts of the USA. For example, collectivism is highest in the southern states while individualism is highest in the Mountain West and Great Plains states. They also found Hawaii to be collectivistic due to the large number of Asian descendants living in the state. Japan is known to be a collectivistic country, but the residents of Hokkaido demonstrate individualistic behaviours as they share similar historical features as the American Wild West (Kitayama et al., 2006). Moreover, levels of trait individualism and collectivism have been known to be influenced by socio-economic status (Kitayama and Uskul, 2011; Na et al. (2010)). Socio-economic status consists of economic and educational resources (Hauser and Warren, 1997), which can lead to variations in urbanization and industrialization. Higher socio-economic status within a society is positively associated with attributes of independence (Kitayama and Uskul, 2011). Na et al. (2010) found that individuals who are highly educated and working in prestigious occupations tend to be more analytical when attending to an object, categorise semantically rather than thematically, and have a more linear and formal view of change.

Mass media can be used to stimulate and influence attitudes and behaviours (Sulong and Abdullah, 2010) and create a new form of thought, value and culture as well as play a role in the formation of personality (Bakhori, 2012, as cited in Hamdan and Ismail, 2019). The globalization of mass media such as Hollywood films has been found to impact the values and ideology of youths in Asia. Maisuwong (2012) observed that Thai youths are adopting the thoughts and behaviours similar to the concept of freedom and independence portrayed in the films. Similarly, Naeem et al., (2020) also found that Pakistani youths are being influenced by American cultural ideals shown in Hollywood films. The popularity of Korean dramas and Japanese animation have also led to an interest in Malaysian youths to learn these languages (Chan and Wong, 2017; Hamdan and Ismail, 2019), and both Korean and Japanese speakers have been shown to have a stronger holistic attentional bias (Rhode et al., 2016; Tajima et al., 2012).

Based on the evidence just presented, it can be said that individualism and collectivism on a personal trait basis can be influenced by various external factors such as geographical locations, socio-economic status and mass media. Therefore, it is prudent to take into account the limitations of classifying individuals into individualistic/collectivistic groups solely based on their nationalities. Therefore, Sharma (2010) developed a 40-item questionnaire where he formalised Hofstede's (1980, 2001) cultural factors (individualism-collectivism, power distance, masculinity-femininity, uncertainty avoidance, long/short term orientation) to be sensitive enough to measure cultural orientation on an individual level. This questionnaire was called the personal cultural orientation questionnaire and will be used to split participants into individualistic and collectivistic groups.

This study aimed to 1) replicate the effect of learned predictiveness in individualistic participants and the absence of learned predictiveness in collectivistic participants; 2) replicate the moderating effects of culture on the relationship between conscientiousness and relevant stimuli by looking at individualism and collectivism on both national and individual level by employing a cultural orientation questionnaire; 3) demonstrate whether schizotypy predicts learned predictiveness and 4) determine whether the effects of learned predictiveness could be replicated in an online environment. The third and fourth aim of this study was proposed because despite the previous literature on how schizotypy plays a role in learned predictiveness (Haselgrove et al., 2016; Le Pelley et al., 2010), results from the Bayesian linear regression were anecdotal and required further data collection. However, due to the COVID-19 pandemic, data collection had to be conducted online.

On the basis of the results from Study 5, it is predicted that there will be cultural differences in the magnitude of learned predictiveness, where participants from the individualistic group will better discriminate between the relevant and irrelevant stimuli, consequently providing higher ratings for the former than the latter, but participants from the collectivistic group will not. Secondly, this study predicted that the food allergist task used would be adequate to generate learned predictiveness in an online experiment as Study 6 on conducting a latent inhibition task online was successful. Since personality traits in general have been shown to be stable across time and can endure across different social contexts (Maltby et al. 2017), and the Big 5 have been shown to have good cross-cultural validity (Rolland, 2002), if participants were to be separated by a more sensitive measurement of cultural orientation, the effect of conscientiousness predicting learning about the relevant stimuli should be able to be replicated. Finally, this study predicted that schizotypy might play a role in learned predictiveness as there was anecdotal evidence in the previous study. Additionally, albeit scarce, there has been evidence of schizotypy mediating learning about relevant stimuli in a learned predictiveness task (Haselgrove et al., 2016; Le Pelley et al., 2010).

6.2: Methods

6.2.i: Participants

263 participants were recruited from the University of Nottingham UK, the University of Nottingham Malaysia Campus and Prolific (online recruitment platform). There were 84 males and 179 females. The age of the participants ranged from 18 to 30 years old, (M = 21.26, SD = 3.22). Participants from the universities were recruited through the school's Research Participation Scheme, recruitment posters and word of mouth. In the Malaysian campus, first year psychology undergraduates were compensated with course credit and the rest of the participants were compensated with Ringgit Malaysia 10. In the UK campus, first year psychology undergraduates were compensated with course credit and participants from Prolific were compensated with £6.

6.2.ii: Questionnaires

The O-LIFE (Mason and Claridge, 2006), Big 5 (Goldberg, 1992) questionnaire from Experiment 4 was used. The personal cultural orientation questionnaire developed by Sharma (2010) was used as it provides a more accurate measure of cultural factors in personality compared to Hofstede's national scores. This questionnaire consists of 40 items on a 7-point Likert scale, ranging from 1 being "strongly disagree" to 7 being "strongly agree". An example of an item is "I would rather depend on myself than others", see Appendix D for other questions and screenshot of questionnaire on Qualtrics.

6.2.iii: Procedure

Participants completed the experiment on their own personal devices such as their laptops or desktop computers as this experiment is not compatible with smartphones or tablets. They were advised to run the task on Google Chrome. Participants were given a Qualtrics link. First, they were asked to click on a link that directed them to the Pavlovia site where they completed the food allergist task that was identical to the task described in Study 5. This task involved presenting participants with food compounds and asking them to determine which foods caused which allergies. After that, they were asked to provide ratings of the likelihood of certain food compounds causing certain allergic reactions. At the end of the task, participants were asked to return to the Qualtrics page where they were asked to complete the 3 questionnaires (i.e., the OLIFE, the Big 5 and the personal cultural orientation questionnaire), and these questionnaires were presented in a varied order using Qualtrics' randomiser function. Finally, participants recruited from Prolific were redirected back to the website to confirm that they have completed the experiment. It took participants less than an hour to complete all the tasks.

6.3: Results

This section will first describe on what basis participants will be removed from analysis. It will then describe how participants were separated into individualistic and collectivistic groups using cluster analysis. The treatment of behavioural and psychometric data was the same as in Chapter 4 (see Chapter 4: Results/Data treatment). Next, the analysis of the learned predictiveness behavioural data will be discussed. The behavioural data will also be split by culture to analyse. This is followed by a comparison of the lab-based (Chapter 4) and the current online data to determine if there are differences when conducting the task in two different types of environment. After these analyses, the psychometric data will be analysed and a comparison with the normative data will be presented. Participants will be split into individualistic and collectivistic groups again to determine if there are cultural differences in personality traits predicting learned predictiveness.

To determine if there were any correlations between personality traits and learned predictiveness, a polychoric correlation rather than a Pearson/Spearman correlation was conducted as it is the most consistent and robust estimator for ordinal variables (Holgado-Tello et al., 2009). A parallel approach of using both frequentist and Bayesian linear regressions will be used because Bayesian analysis can discern whether a $p > 0.05$ is the result of a true null effect or an insensitivity of the data to reveal an effect. Dienes (2014) states that a Bayes Factor of < 0.33 is in support of the null hypothesis, a Bayes Factor of > 3 is support of the alternative hypothesis and a Bayes Factor of > 0.33 but < 3 is evidence of a weak or anecdotal effect and requires further data collection.

To further determine if culture plays a role in how personality traits affect learned predictiveness, a simple moderation analysis was used because culture (individualistic/collectivistic) was a dichotomous variable. As the data are nonparametric, this analysis will be conducted by bootstrapping with $n_{samples} = 1000$ (Kline, 2011).

Part A: Data treatment

16 participants were eliminated due to not completing the behavioural task. All participants completed the questionnaires. The final n = 247. A hierarchical cluster analysis was conducted using SPSS and the number of clusters were set to 2 to correspond to i) trait individualism (i.e., high in individualistic and low in collectivistic traits) and ii) collectivism (i.e., high in collectivistic and low in individualistic traits), the individualistic group has n = 185 while the collectivistic group has n = 62.

The raw data were downloaded from Gitlab, an online repository where the data collected was saved and stored. These data were then used to calculate a “relevant score”, “irrelevant score” and “learned predictiveness” score, procedure as described in Study 1.

The subscale of interest from the personal cultural orientation questionnaire was independence, from here on will be termed ‘individualism’, and interdependence, from here on will be termed ‘collectivism’. This is because the terms individualism/independence and collectivism/interdependence share similar meaning and can be used interchangeably (Markus and Kitayama, 2010). Moreover, this is to ensure continuity from the previous chapters.

A reliability analysis was conducted for the OLIFE, Big 5 and personal cultural orientation questionnaires. The values are as follows: 1) OLIFE ([unusual experiences, introvertive anhedonia, cognitive disorganization, impulsive nonconformity], McDonald’s omega = 0.88, 0.82, 0.87, 0.66 respectively); 2) Big 5 ([openness, conscientiousness, extraversion, agreeableness and emotional stability], McDonald’s omega = 0.71, 0.76, 0.83, 0.76, 0.75 respectively); personal cultural orientation ([individualistic, collectivistic], McDonald’s omega = 0.62, 0.64 respectively). According to Feißt et al. (2019), a score of more than 0.80 is considered to have good internal reliability.

Part B1: Analysis of behavioural data

Figure 6.1a shows the mean proportion of correct responses increased as training progressed. A one-way repeated measures ANOVA revealed there was a difference in mean proportion correct across trials, $F(8.81, 2167.35) = 69.08$, $p < 0.001$, $\eta^2_p = 0.22$, indicating that performance improved as training progressed. A one sample t-test was conducted (test value = 0.5) on trial 12 to determine if responding was above chance (50%); there was a significant difference, $t(246) = 24.99$, $p < 0.001$, $d = 1.59$.

As seen from Figure 6.1b, the mean proportion correct responses increased across training in Stage 2 and that, also, the mean proportion correct for trials with EF/GH/IJ/KL was higher than AX/BY/CV/DW. A 2(stimuli) x 6 (trials) repeated measures ANOVA was conducted and revealed a there was a main effect of stimuli, $F(1, 246) = 37.26$, $p < 0.001$, $\eta^2_p = 0.13$, a main effect of trials, $F(4.54, 1116.11) = 82.64$, $p < 0.001$, $\eta^2_p = 0.25$ and also a significant interaction between stimuli and trials, $F(4.66, 1145.35) = 3.72$, $p = 0.003$, $\eta^2_p = 0.02$. Post-hoc analyses revealed a main effect of trials for both types of stimuli, largest $F(4.48, 1102.00) = 62.02$, $p < 0.001$, $\eta^2_p = 0.20$, suggesting accuracy of responses for both types of stimuli increased with more training experienced. A further analysis using a simple effect analysis revealed that accuracies for EF/GH/IJ/KL trials were significantly higher than the AX/BY/CV/DW from trials 3 to 6 ($p < 0.05$). One sample t-tests revealed that performance in both stimuli on trial 6 was significantly above chance (50%) smallest $t(246) = 13.77$, $p < 0.001$, $d = 0.88$.

Figure 6.2 shows the mean difference ratings for the four stimuli and a one-way repeated measures ANOVA revealed a significant difference among the stimuli, $F(2.85, 699.99) = 70.64$, $p < 0.001$, $\eta^2_p = 0.22$, see Figure 6.2. A Bayesian paired samples t-test was conducted between the relevant ($M = 2.82$, $SE = 0.27$) and irrelevant ($M = 2.08$, $SE = 0.25$) stimuli and there was a significant difference, $t(246) = 2.30$, $p = 0.01$, BF10 = 1.85, $d = 0.15$. Consistent with previous results in Chapter 4, EH/FG ($M = -0.37$, $SE = 0.24$) had the lowest ratings, indicating little learning while IJ/KL ($M = 4.63$, $SE = 0.30$) had the highest ratings, indicating most learning, $t(246) = -13.00$, $p < 0.001$, $BF_{10} > 3$, $d = -0.83$.

a) b)

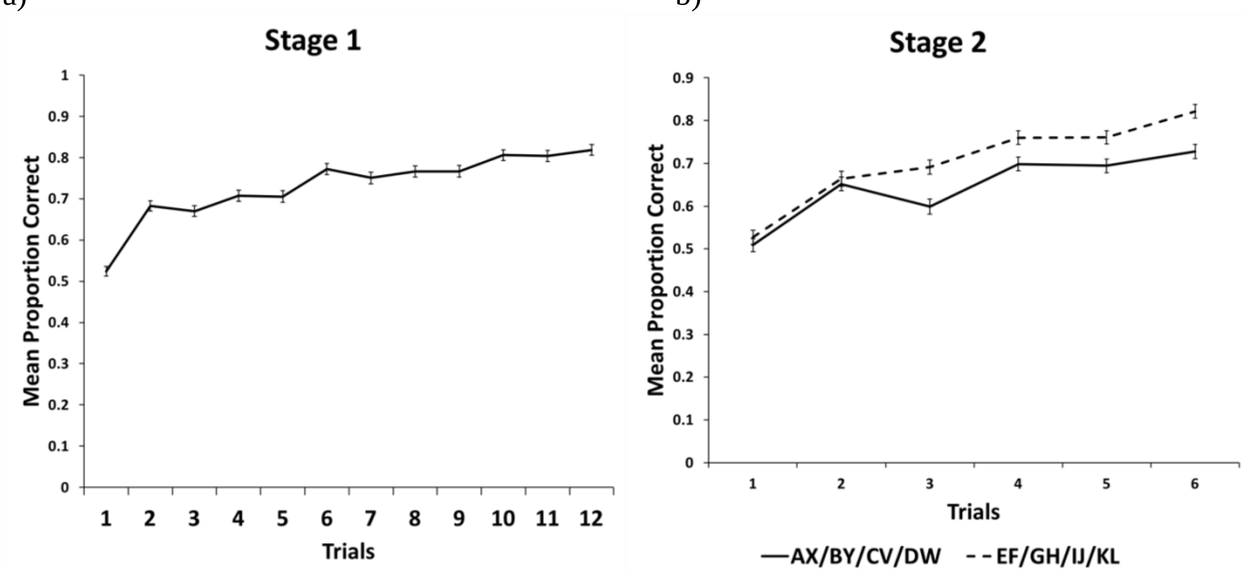


Figure 6.1: Mean proportion correct across trials in Stage 1 and 2 in Study 7. Error bars represent standard error of mean.

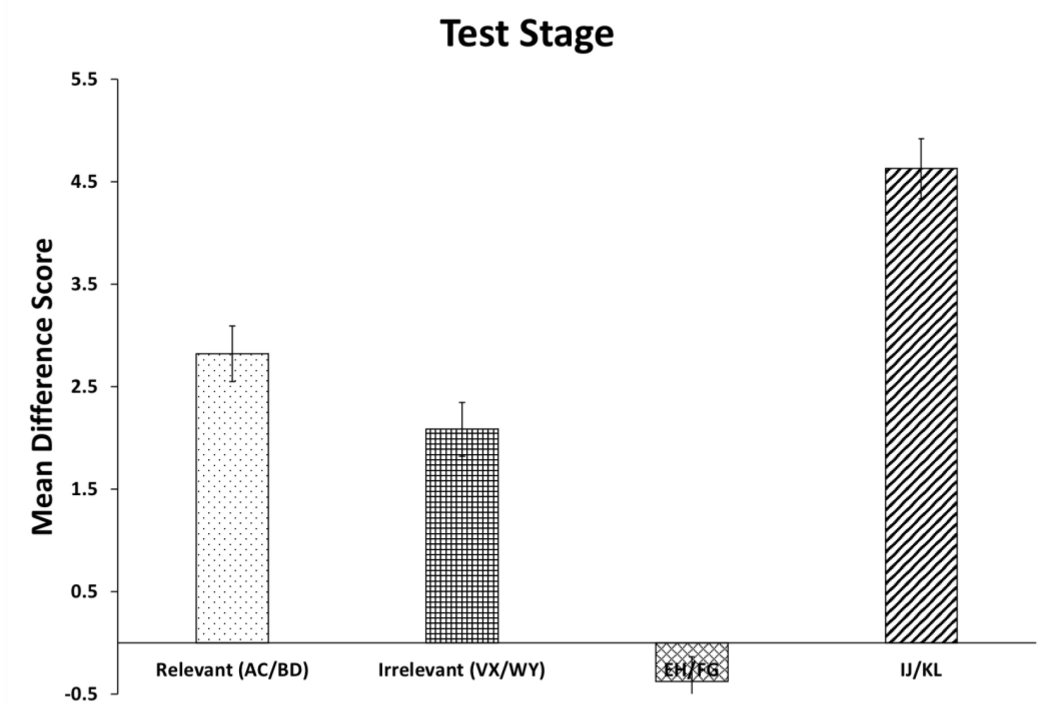


Figure 6.2: Mean proportion difference in rating of stimuli in Study 7. Error bars represent standard error of mean.

B2: Cultural differences in learned predictiveness

Figure 6.3a shows the mean proportion of correct responses increased across the 12 training trials of Stage 1. A 2 (culture) x 12 (trials) mixed design ANOVA was conducted to determine if the two cultures differed in learning of the cues across trials. There was no main effect of culture, $F(1, 245) = 2.21$, $p = 0.14$, $\eta^2_p = 0.01$ and a main effect of trials, $F(8.83, 2164.30) = 58.91$, $p < 0.001$, $\eta^2_p = 0.19$. There was no significant interaction effect $F(8.83, 2164.30) = 1.08$, $p = 0.38$, $\eta^2_p = 0.004$. One sample t-tests revealed that performance in both groups on trial 12 was significantly above chance (50%) smallest $t(61) = 15.65$ $p < 0.001$, $d = 1.99$.

Figure 6.3b shows that the mean proportion correct for both types of stimuli increased across the 6 training trials for both cultures. A 2 (culture) x 2 (stimuli) x 6 (trials) mixed design ANOVA was conducted and there was no main effect of culture, $F(1, 245) = 0.12$, $p = 0.74$, $\eta^2_p < 0.001$. There was a main effect of stimuli, $F(1, 245) = 19.34$, $p < 0.001$, $\eta^2_p = 0.07$, and a main effect of trials, $F(4.54, 1112.79) = 67.54$, $p < 0.001$, $\eta^2_p = 0.22$. The interaction effect of stimuli and trials just approached significance, $F(4.65, 1139.51) = 2.25$, $p = 0.05$, $\eta^2_p = 0.01$. The three-way interaction and other two-way interactions were not significant, largest $F(1, 245) = 3.42$, $p = 0.07$, $\eta^2_p = 0.01$. Post-hoc analyses revealed a main effect of trials for both types of stimuli in both groups, largest $F(4.49, 825.62) = 44.58$, $p < 0.001$, $\eta^2_p = 0.20$, suggesting accuracy of responses for both types of stimuli increased with more training experienced in both groups. One sample t-tests revealed that performance in both stimuli on trial 6 for both cultures was significantly above chance (50%) smallest $t(61) = 9.80$, $p < 0.001$, $d = 1.24$.

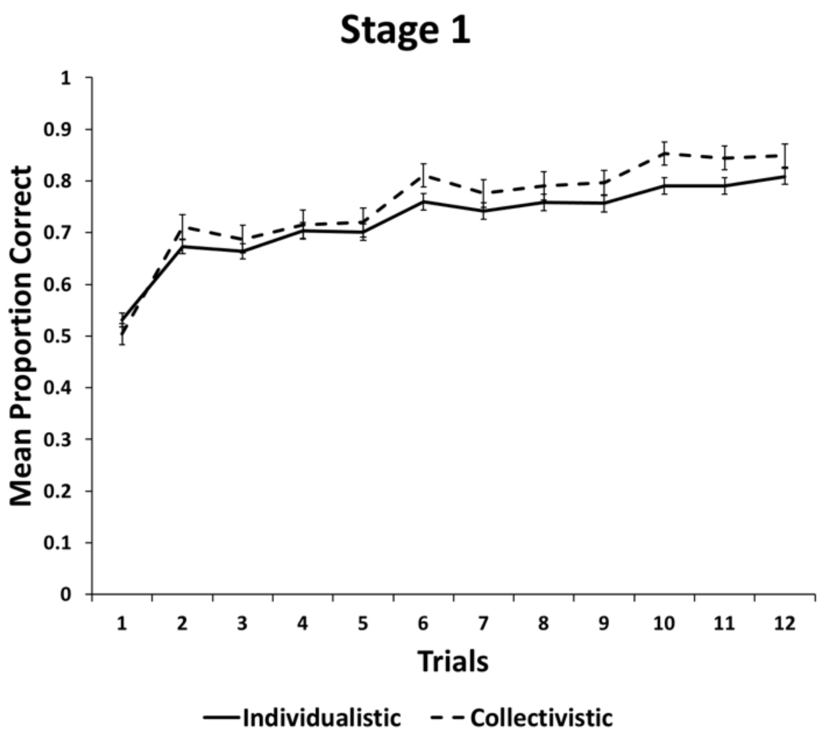
Figure 6.4a shows the mean ratings provided by participants in the test stage for the relevant and irrelevant stimuli types. A 2 (relevance) x 2 (culture) mixed design ANOVA was conducted and there was no main effect of relevance, $F(1, 245) = 1.41$, $p = 0.24$, $\eta^2_p = 0.01$, but a main effect of culture, $F(1, 245) = 4.85$, $p = 0.03$, $\eta^2_p = 0.02$. There was no interaction effect $F(1, 245) = 2.64$, $p = 0.11$, $\eta^2_p = 0.01$. Although the interaction effect was not significant, a Bayesian paired samples t-tests were conducted for the individualistic and collectivistic group between the relevant (individualistic = $M = 2.71$, $SE = 0.30$; collectivistic = $M = 3.15$, $SE = 0.59$) and irrelevant stimuli (individualistic = $M = 1.67$, $SE = 0.28$; collectivistic = $M = 3.31$, $SE = 0.52$) to determine if the previous findings where learned predictiveness is found in the former but not latter group can be replicated. The analyses revealed a significant difference in the individualistic group $t(184) = 2.83$,

$p = 0.003$, $BF_{10} = 7.86$, $d = 0.21$, but not the collectivistic group, $t(61) = -0.25$, $p = 0.60$, $BF_{10} = 0.12$, $d = -0.03$.

Figure 6.4b shows the mean ratings provided by participants in the test stage for the stimuli that has been consistently shown different outcomes (EH/FG) and consistently the same outcomes (IJ/KL) in Stage 2. Since this Study aimed to replicate Study 5, to ensure continuity in the statistical analyses, a 2 (stimuli) x 2 (culture) mixed design ANOVA was conducted with the EH/FG/IJ/KL stimuli and there was a main effect of stimuli, $F(1, 245) = 141.18$, $p < 0.001$, $\eta^2_p = 0.37$, but no main effect of culture, $F(1, 245) = 0.13$, $p = 0.72$, $\eta^2_p = 0.001$. There was no interaction effect $F(1, 245) = 1.53$, $p = 0.22$, $\eta^2_p = 0.01$. Despite the non-significant interaction effect and main effect of culture, to answer the theoretical aspect of whether there would be a difference between groups in learning with this alternative method of grouping participants using trait individualism and collectivism, between subjects t-tests were conducted.

It was revealed that the relevant stimuli, learned predictiveness score, IJ/KL and EH/FG showed no significant difference, smallest $t(245) = -0.70$, $p = 0.49$, $BF_{10} = 0.20$, $d = -0.10$). There was a significant difference *irrelevant stimuli*, $t(245) = -2.88$, $p = 0.004$, $BF_{10} = 7.34$, $d = -0.42$).

a)



b)

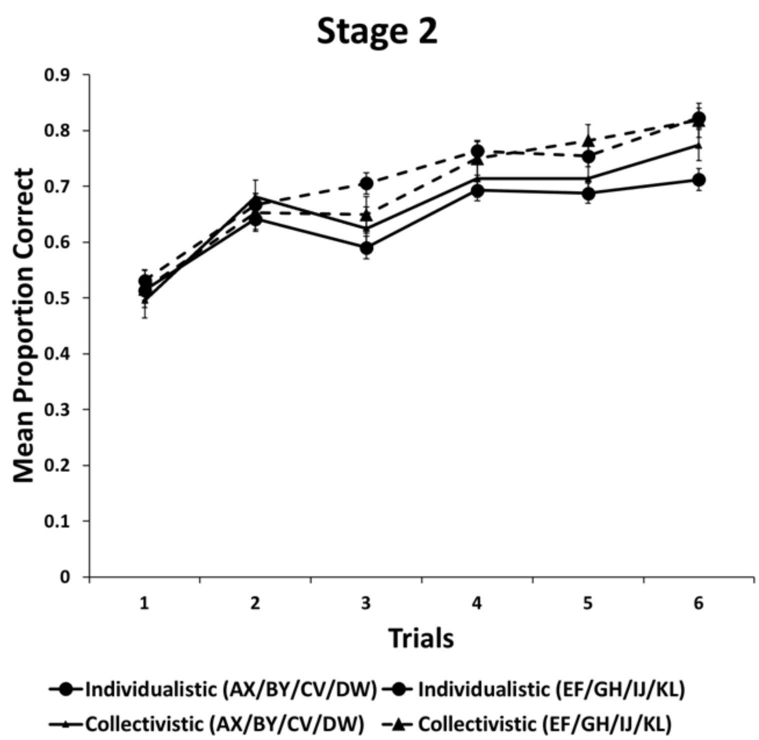
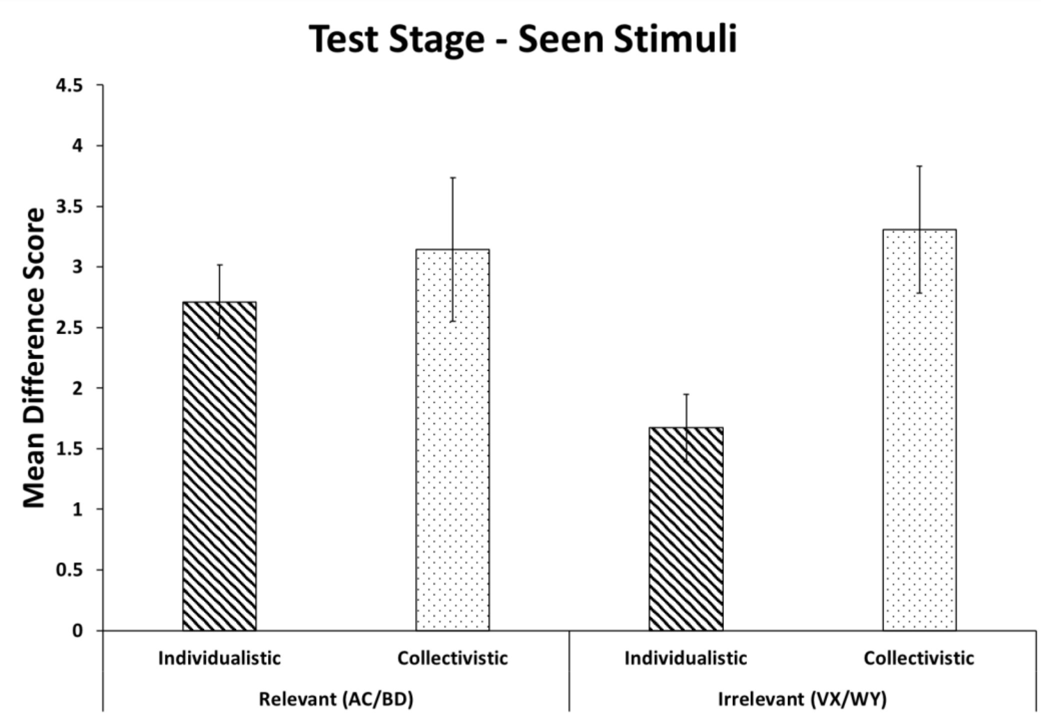


Figure 6.3: Mean proportion correct across trials in Stage 1 and 2 separated by culture in Study 7. Error bars represent standard error of mean.

a)



b)

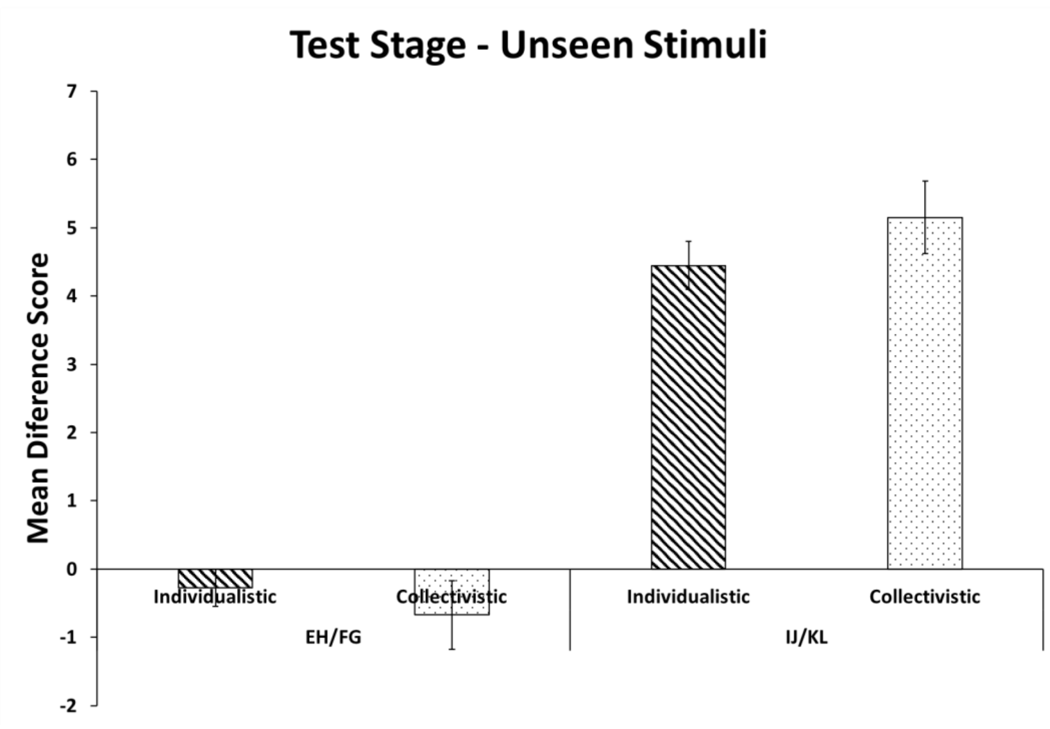


Figure 6.4: Mean difference rating of stimuli separated by culture for, a) AC/BD/VX/WY and b) EH/FG/IJ/KL stimuli in Study 7. Error bars represent standard error of mean.

B3: Differences between lab-based and online experiments

Table 6.1 shows the mean and standard error of mean of the difference score to the relevant and irrelevant stimuli and the learned predictiveness score. To determine if there was a difference in learned predictiveness when the task is conducted in-person or online and between cultures, a 2 (testing format) x 2 (culture) x 2 (relevance on stimuli) mixed design ANOVA was conducted. There was a main effect of stimuli, $F(1, 506) = 15.61$, $p < 0.001$, $\eta^2_p = 0.03$, but no main effect of testing format and culture, largest $F(1, 506) = 0.17$, $p = 0.90$, $\eta^2_p < 0.001$. There was no significant difference for all of the two-way and three-way interactions, largest $F(1, 506) = 3.02$, $p = 0.08$, $\eta^2_p = 0.01$. These therefore suggests that there were no differences between the learned predictiveness effect in lab-based or online experiments.

Table 6.1: Means and standard error of mean of relevant stimuli, irrelevant stimuli and learned predictiveness score for both lab-based and online experiments.

	Experiment	N	Mean	SE
Relevant	Lab	263	2.98	0.26
	Online	216	2.73	0.29
Irrelevant	Lab	263	2.04	0.24
	Online	216	1.99	0.27
LPScore	Lab	263	0.95	0.32
	Online	216	0.74	0.35

B4: Summary of findings

Initial analysis revealed that all participants demonstrated learned predictiveness. However, upon further analysis, only the individualistic culture showed learned predictiveness. There was also no difference in terms of performance of participants between a lab-based and online task of learned predictiveness.

Part C: Comparison with normative data

Table 6.2 shows the OLIFE and Big 5 scores and standard deviations for each subscale as well as the scores and standard deviations for STICSA's trait subscale and the individualistic and collectivistic subscales of the personal cultural orientation questionnaires. The data presented includes participants from Study 5, 6 and 7 along with normative data from Mason et al. (1995) – OLIFE, Gros et al. (2007) – STICSA and Sharma (2010) – personal cultural orientation. The sample means for unusual experiences (except in Study 5) and STICSA (trait) were not significantly different from normative values, largest $t(440) = 1.57$, $p = 0.12$. The other subscales of the OLIFE were significantly different than the normative data, largest $t(769) = 7.16$, $p < 0.001$.

Table 6.3 shows correlations between subscales of the OLIFE. The matrix follows a similar pattern to that of Mason et al. (1995). Table 6.4 shows the correlations between subscales of the Big 5 but since no normative data was published, a comparison could not be made. Since only trait anxiety was used, there was no need to conduct a correlation test for it.

Table 6.2: Descriptive statistics for OLIFE, Big 5, trait anxiety and personal cultural orientation subscales in Study 5, 6, 7 and normative data.

		Mean Score (SD)											
Subscales	Number of items	Study 5			Study 6			Study 7			Normative		
		All	Ind	Col	All	Ind	Col	All	Ind	Col	All	Ind	Col
		n = 263	n = 102	n = 161	n = 131	n = 80	n = 51	n = 247	n = 185	n = 62	n = 508		
OLIFE													
Unusual Experiences	30	10.7 (6.0)	8.2 (5.2)	12.3 (5.9)	10.6 (5.8)	10.7 (6.0)	10.4 (5.6)	10.5 (6.4)	10.0 (6.7)	11.2 (6.0)	9.7 (6.7)	NA*	NA*
Introvertive Anhedonia	27	7.5 (4.8)	5.3 (4.5)	8.9 (4.5)	9.0 (5.5)	8.9 (5.4)	9.2 (5.8)	7.5 (4.9)	7.1 (4.9)	7.9 (5.0)	6.1 (4.6)	NA*	NA*
Cognitive Disorganisation	24	14.7 (5.5)	13.4 (5.6)	15.6 (5.3)	14.9 (5.7)	15.2 (5.6)	14.4 (6.0)	14.1 (5.7)	13.5 (5.8)	14.7 (5.6)	11.6 (5.8)	NA*	NA*
Impulsive Nonconformity	23	7.6 (3.9)	7.6 (4.2)	7.7 (3.7)	7.9 (4.2)	8.1 (4.2)	7.6 (4.1)	7.7 (3.5)	7.8 (3.5)	7.6 (3.6)	9.1 (4.3)	NA*	NA*
Big 5													
Openness	7	6.6 (1.0)	6.6 (0.9)	6.5 (1.0)	6.6 (1.2)	6.7 (1.1)	6.5 (1.2)	6.8 (1.0)	7.0 (0.9)	6.5 (0.9)	NA**	NA**	NA**
Conscientiousness	7	6.2(1.2)	6.5 (1.1)	5.9 (1.2)	6.0 (1.3)	6.1 (1.4)	6.0 (1.2)	6.4 (1.2)	6.7 (1.1)	6.0 (1.2)	NA**	NA**	NA**
Extraversion	7	5.8 (1.4)	6.2 (1.3)	5.6 (1.4)	5.1 (1.5)	5.2 (1.4)	5.0 (1.6)	5.7 (1.4)	5.8 (1.5)	5.5 (1.3)	NA**	NA**	NA**
Agreeableness	7	6.6 (1.2)	6.9 (1.1)	6.5 (1.2)	6.3 (1.3)	6.4 (1.4)	6.3 (1.2)	6.7 (1.1)	6.7 (1.1)	6.6 (1.0)	NA**	NA**	NA**
Emotional Stability	7	5.2 (1.3)	5.3 (1.4)	5.2 (1.3)	5.2 (1.3)	5.2 (1.3)	5.1 (1.3)	5.4 (1.2)	5.5 (1.3)	5.2 (1.2)	NA**	NA**	NA**
STICSA											n = 311		
Trait	21	37.7 (11.2)	36.5 (11.0)	38.5 (11.2)	38.7 (10.3)	39.0 (9.6)	38.4 (11.3)	NA***	NA***	NA***	37.0 (10.4)	NA*	NA*
PCO									n = 133	n = 114	n = 1744	n = NA	n = NA****
Individualism	4	NA***	NA***	NA***	NA***	NA***	NA***	5.5 (0.9)	5.5 (0.8)	5.5 (1.0)	NA	5.3 (1.0)	4.3 (1.1)
Collectivism	4	NA***	NA***	NA***	NA***	NA***	NA***	5.4 (0.9)	5.3 (1.0)	5.4 (0.9)	NA	5.3 (1.4)	4.5 (1.7)

* No normative data for the OLIFE split by culture could be found.

** Unfortunately, the original authors and the authors who conducted the reliability and validity study did not provide the normative data.

*** The questionnaires were not conducted.

**** The original author only included Chinese nationals in the collectivistic group while this study included nationals from any collectivistic countries as defined by the Hofstede database. However, it should be noted that in Study 7 for the OLIFE and Big 5 questionnaires, participants were not grouped based on nationality but based on their PCO scores.

Table 6.3: Correlation matrix for OLIFE subscales. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

	Study 5 (n = 263)			Study 6 (n = 133)			Study 7 (n = 247)			Normative (n = 508)		
	InAn	CogDis	ImpNon	InAn	CogDis	ImpNon	InAn	CogDis	ImpNon	InAn	CogDis	ImpNon
UnEx	0.20***	0.48***	0.35***	0.19*	0.32***	0.64	0.06	0.47***	0.45***	0.08	0.42**	0.46**
InAn	1.00	0.38***	0.10	1.00	0.4***	0.03	1.00	0.23***	-0.04	1.00	0.25**	0.10**
CogDis		1.00	0.50***		1.00	0.17***		1.00	0.35***		1.00	0.33**
ImpNon			1.00			1.00			1.00			1.00

Table 6.4: Correlation matrix for Big 5 subscales. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

	Study 5 (n = 263)				Study 6 (n = 131)				Study 7 (n = 247)			
	C	E	A	ES	C	E	A	ES	C	E	A	ES
Openness	0.38***	0.39***	0.34***	0.27***	0.5***	0.46***	0.50***	0.17***	0.41***	0.35***	0.25***	0.23***
Conscientiousness	1.00	0.26***	0.47***	0.33***	1.00	0.41***	0.55***	0.34***	1.00	0.15*	0.36***	0.37***
Extraversion		1.00	0.52***	0.44***		1.00	0.48***	0.35***		1.00	0.41***	0.33***
Agreeableness			1.00	0.44***			1.00	0.41***			1.00	0.41***
Emotional Stability				1.00				1.00				1.00

Part D: Effects of personality traits on learned predictiveness

To investigate the relationship between the Big 5 and schizotypy and learned predictiveness, polychoric correlations were conducted. Next, a frequentist and Bayesian regression were conducted with the personality traits and subscales as the predictors of response times to the difference scores to the relevant and irrelevant stimuli and learned predictiveness score. If any personality traits of subscale were found to be significant and whose $BF_{inclusion}$ was either supporting the alternative hypothesis (>3) or anecdotal ($0.33 < BF_{inclusion} < 3$), a simple moderation was conducted.

D1: The Big 5

When all the participants were analysed together, it was revealed that extraversion was positively correlated with difference scores to the irrelevant stimuli. When the participants were split into individualistic and collectivistic groups, only the individualistic group showed a trend of a positive correlation between extraversion and irrelevant stimuli, see Table 6.2.

To determine if there was a relationship between the Big 5 and learned predictiveness, Bayesian linear regressions were conducted with the Big 5 personality traits as a predictor for relevant and irrelevant stimuli as well as LPScore for all participants was conducted and there was a significant relationship found for irrelevant stimuli, $F(5, 241) = 2.22$, $p = 0.05$, $R^2 = 0.04$, adjusted $R^2 = 0.02$. There was no significant relationship for difference scores to the relevant stimuli and LPScore, largest $F(5, 241) = 1.61$, $p = 0.16$, $R^2 = 0.03$, adjusted $R^2 = 0.01$. After splitting by culture, the Big 5 did not significantly predict the difference scores to the relevant stimuli, irrelevant stimuli and LPScore, largest $F(5, 56) = 1.33$, $p = 0.27$, $R^2 = 0.11$, adjusted $R^2 = 0.03$.

Table 6.3 shows the summary of coefficients for the Bayesian linear regression. It was revealed that extraversion was a positive predictor of ratings to the irrelevant stimuli, which means that participants high in extraversion learn more about irrelevant stimuli than participants low in extraversion. The $BF_{inclusion}$ value supports this finding as it is > 3. It was also revealed that extraversion was negative predictor of learned predictiveness score, meaning that participants high in extraversion show diminished learned predictiveness. However, the $BF_{inclusion}$ value indicates that this finding is anecdotal.

For the individualistic group, it was revealed that extraversion was positively predicting difference scores to the irrelevant stimuli and negatively predicting learned predictiveness score. This means that participants from the individualistic group who are high in extraversion learn the irrelevant stimuli better and show diminished learned predictiveness effects. However, the BFinclusion value indicates that these findings are anecdotal. For the collectivistic group, consistent with the correlation analyses, none of the Big 5 personality traits predict learned predictiveness in the collectivistic group [8].

Footnote 8: According to GPower, the recommended sample size for a regression with five predictors is n = 72 with a medium effect size. Therefore, this analysis is underpowered by 10 participants.

D1.i: Further analysis: Simple moderation analysis

To determine if culture moderates the relationship between extraversion and difference scores to the irrelevant stimuli ratings, a simple moderation analysis was conducted, see Figure 6.39.

A significant interaction effect was found between openness and culture, $\beta = 0.08$, $p = 0.003$, and a main effect of culture, $\beta = 1.68$, $p = 0.003$, but no main effect of extraversion, $\beta = 0.07$, $p = 0.30$, see Figure 6.5. The moderation analysis revealed that participants high in extraversion showed better learning of the irrelevant stimuli, but this is only present in the collectivistic group (estimate = 0.11, z-score = 2.71, p = 0.01) and not in the individualistic group (estimate = 0.05, z-score = 1.32, p = 0.19), see Figure 6.6 for simple slope plot illustrating this relationship. This is unexpected as the regression analysis has been showing that the predicting effect of extraversion is shown in the individualistic culture. The reason why this could have happened will be discussed in the general discussion of this chapter.

Table 6.5: Summary of correlations from all participants and split by culture of the relationship between the Big 5 personality traits and learned predictiveness in Study 7. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings.

Big 5	Relevant (r)	Irrelevent (r)	LPScore (r)
All (n = 247)			
Openness	0.05	0.03	0.02
Conscientiousness	0.02	-0.06	0.06
Extraversion	0.02	0.19*	-0.13
Agreeableness	0.07	0.01	0.05
Emotional Stability	0.04	0.04	0.01
Individualistic (n = 185)			
Openness	0.08	0.10	-0.01
Conscientiousness	0.04	0.03	0.01
Extraversion	-0.02	0.16*	-0.14
Agreeableness	0.06	0.01	0.05
Emotional Stability	0.01	0.02	-0.01
Collectivistic (n = 62)			
Openness	0.02	0.01	0.01
Conscientiousness	0.01	-0.04	0.04
Extraversion	0.14	0.29	-0.10
Agreeableness	0.11	0.07	0.05
Emotional Stability	0.16	0.16	0.02

Table 6.6: Summary of the Big 5 personality traits as coefficients and the difference scores to the relevant stimuli, irrelevant stimuli and learned predictiveness score as dependent variables in Study 7. *Note*: $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$

Coefficients	**Relevant**		**Irrelevant**		**LPScore**	
Big 5	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All (n = 247)						
Openness	0.05	0.06	-0.003	0.18	0.05	0.13
Conscientiousness	-0.04	0.05	-0.07	0.28	0.03	0.14
Extraversion	-0.03	0.05	0.22**	3.18	-0.19*	0.48
Agreeableness	0.08	0.07	-0.05	0.22	0.10	0.20
Emotional Stability	0.02	0.05	0.01	0.17	0.01	0.11
Individualistic (n = 185)						
Openness	0.10	0.09	0.05	0.16	0.04	0.11
Conscientiousness	-0.004	0.07	0.01	0.11	-0.01	0.1
Extraversion	-0.08	0.07	0.18*	0.55	-0.21*	0.37
Agreeableness	0.08	0.08	-0.08	0.13	0.13	0.17
Emotional Stability	-0.01	0.06	-0.02	0.12	0.004	0.11
Collectivistic (n = 62)						
Openness	-0.06	0.15	-0.09	0.27	0.02	0.13
Conscientiousness	-0.08	0.15	-0.10	0.27	0.01	0.13
Extraversion	0.09	0.19	0.28	0.95	-0.14	0.16
Agreeableness	0.07	0.17	-0.02	0.26	0.08	0.13
Emotional Stability	0.15	0.22	0.14	0.33	0.02	0.13

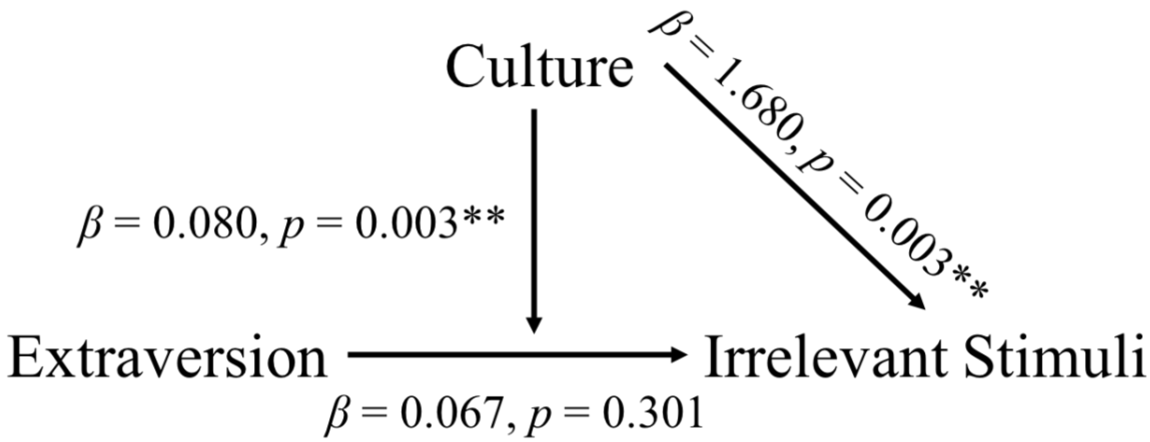


Figure 6.5: Illustration of the relationship between extraversion predicting difference scores to the irrelevant stimuli ratings that is moderated by culture (individualistic and collectivistic) demonstrated in Study 7.

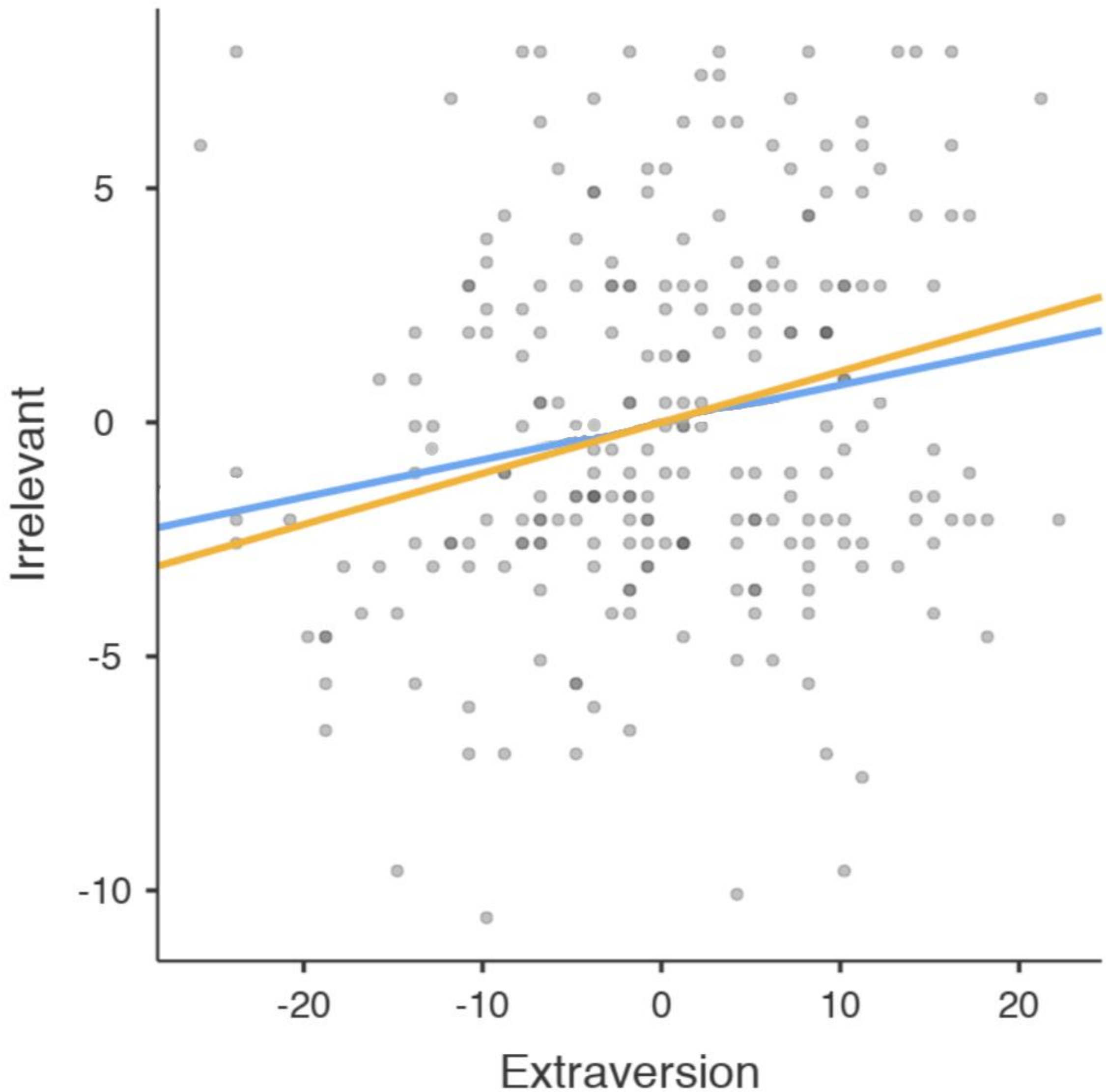


Figure 6.6: Simple slope plot illustrating the relationship between extraversion and ratings from irrelevant stimuli in Study 7. Grey line (low - -1SD) refers to the individualistic group, and the orange line (high - +1SD) refers to the collectivistic group

D2: Schizotypy

To investigate the relationship between the OLIFE subscales and learned predictiveness, polychoric correlations was conducted. When all the participants were analysed together, there was also a trend for introvertive anhedonia to negatively correlate with difference ratings to the irrelevant stimuli. It was also revealed that impulsive nonconformity was negatively correlated with difference ratings to the relevant stimuli. There were no significant correlations for the individualistic group. For the collectivistic group, it was revealed that cognitive disorganization was negatively correlating with the difference scores to the relevant stimuli and introvertive anhedonia was negatively correlated with the difference scores to the irrelevant stimuli in the collectivistic group, see Table 6.4.

To determine if there was a relationship between schizotypy and learned predictiveness, Bayesian linear regressions was conducted with the OLIFE subscales as a predictor for the difference scores to the relevant and irrelevant stimuli as well as LPScore for all participants was conducted and there was a significant relationship found for the difference scores to the relevant stimuli, $F(4, 242) = 2.36$, $p = 0.05$, $R^2 = 0.04$, adjusted $R^2 = -0.02$. There was no significant relationship for the difference scores to the irrelevant stimuli and LPScore, largest $F(4, 242) = 2.06$, $p = 0.09$, $R^2 = 0.03$, adjusted $R^2 = 0.02$. The Bayesian linear regressions were also conducted after splitting participants into individualistic and collectivistic groups. It was found that the Big 5 significantly predicted the difference ratings to irrelevant stimuli only in the *collectivistic* group, $F(4, 57) = 3.20$, $p = 0.02$, $R^2 = 0.18$, adjusted $R^2 = 0.13$. All the other regressions were not significant, largest $F(4, 180) = 2.23$, $p = 0.07$, $R^2 = 0.05$, adjusted $R^2 = 0.03$

Table 6.5 shows the summary of coefficients for the Bayesian linear regression. When all the participants were analysed together, it was revealed that impulsive nonconformity was negatively predicting the difference scores to the relevant stimuli and learned predictiveness score. In other words, participants high in impulsive nonconformity learn less about the difference scores to the relevant stimuli and show diminished learned predictiveness effects. However, the $BF_{inclusion}$ values indicate that these findings are anecdotal.

For the individualistic group, it was revealed that impulsive nonconformity is a negative predictor of the difference scores to the relevant stimuli and learned predictiveness score. This means that participants from the individualistic group who are high in impulsive nonconformity show poorer learning of relevant stimuli and a diminished effect of learning predictiveness. For the collectivistic group, it was revealed that introvertive anhedonia was negatively predicting irrelevant stimuli, reflecting poorer learning of the irrelevant stimuli by participants from the collectivistic group who are high in this subscale. The $BF_{inclusion}$ value supports this finding as it is > 3[9].

D2.i: Simple moderation analysis

To determine if culture moderates the relationship between introvertive anhedonia and difference scores to the irrelevant stimuli, a simple moderation analysis was conducted. A significant interaction effect was found between introvertive anhedonia and culture, β = -0.02, p = 0.02, a main effect of culture, β = 1.52, p = 0.01, and a trending main effect of introvertive anhedonia, β = -0.04, p = 0.07, see Figure 6.7.

Footnote 9: According to GPower, the recommended sample size for a regression with four predictors is n = 72 with a medium effect size. Therefore, this analysis is underpowered by 5 participants.

Participants high in introvertive anhedonia showed retarded learning of the irrelevant stimuli, but this is only present in the collectivistic group (estimate = -0.04, z-score = -2.73, p = 0.01) and not in the individualistic group (estimate = -0.002, z-score = -0.16, p = 0.87), see Figure 6.8 for simple slope plot illustrating this relationship.

Table 6.7: Summary of correlations from all participants and split by culture of the relationship between the OLIFE subscales and learned predictiveness in Study 7. *Note*: $p < 0.05$*. The LPScore was calculated from subtracting the irrelevant stimuli ratings from the relevant stimuli ratings.

OLIFE	Relevant (r)	Irrelevent (r)	LPScore (r)
All (n = 247)			
Unusual Experiences	-0.03	-0.05	0.01
Introvertive Anhedonia	-0.05	-0.15*	0.07
Cognitive Disorganization	-0.12	-0.13	0.00
Impulsive Nonconformity	-0.15*	-0.01	-0.12
Individualistic (n = 185)			
Unusual Experiences	0.05	-0.04	0.07
Introvertive Anhedonia	-0.02	-0.07	0.03
Cognitive Disorganization	-0.05	-0.10	0.03
Impulsive Nonconformity	-0.16	0.01	-0.14
Collectivistic (n = 62)			
Unusual Experiences	-0.24	-0.04	-0.18
Introvertive Anhedonia	-0.13	-0.35*	0.16
Cognitive Disorganization	-0.32*	-0.28	-0.07
Impulsive Nonconformity	-0.15	-0.10	-0.06

Table 6.8: Summary of the OLIFE subscales as coefficients and difference scores to the relevant stimuli, irrelevant stimuli and learned predictiveness score as dependent variables in Study 7. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**Relevant**		**Irrelevant**		**LPScore**	
OLIFE	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All (n = 247)						
Unusual Experiences	0.01	0.24	0.002	0.17	0.09	0.15
Introvertive Anhedonia	-0.04	0.22	-0.12	0.74	0.06	0.16
Cognitive Disorganization	-0.10	0.39	-0.12	0.48	0.003	0.12
Impulsive Nonconformity	-0.16*	0.95	0.03	0.17	-0.16*	0.41
Individualistic (n = 185)						
Unusual Experiences	0.17	0.50	-0.01	0.09	0.15	0.45
Introvertive Anhedonia	-0.03	0.23	-0.05	0.11	0.02	0.21
Cognitive Disorganization	-0.050	0.25	-0.11	0.16	0.04	0.24
Impulsive Nonconformity	-0.22**	1.06	0.05	0.09	-0.22**	0.79
Collectivistic (n = 62)						
Unusual Experiences	-0.08	0.45	0.27	0.80	-0.28	0.53
Introvertive Anhedonia	0.002	0.32	-0.32*	3.31	0.26	0.50
Cognitive Disorganization	-0.27	1.46	-0.25	1.15	-0.05	0.30
Impulsive Nonconformity	-0.02	0.33	-0.14	0.66	0.10	0.29

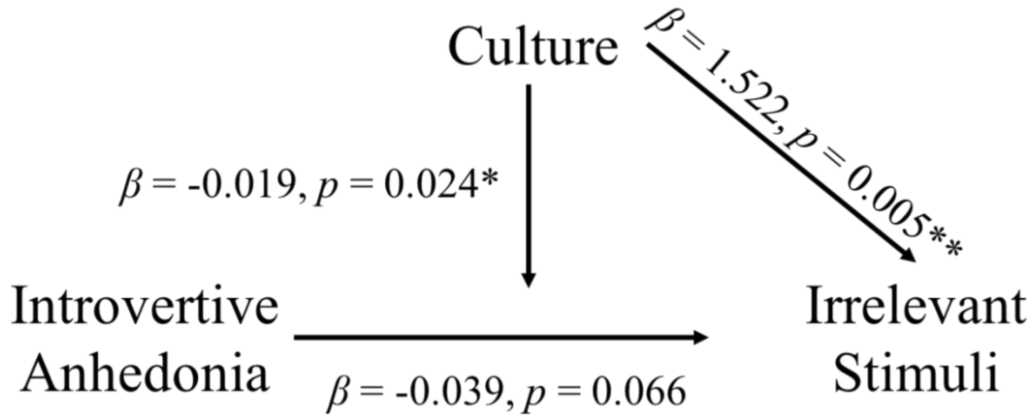


Figure 6.7: Illustration of the relationship between introvertive anhedonia predicting the difference scores to the irrelevant stimuli ratings that is moderated by culture (individualistic and collectivistic) demonstrated in Study 7.

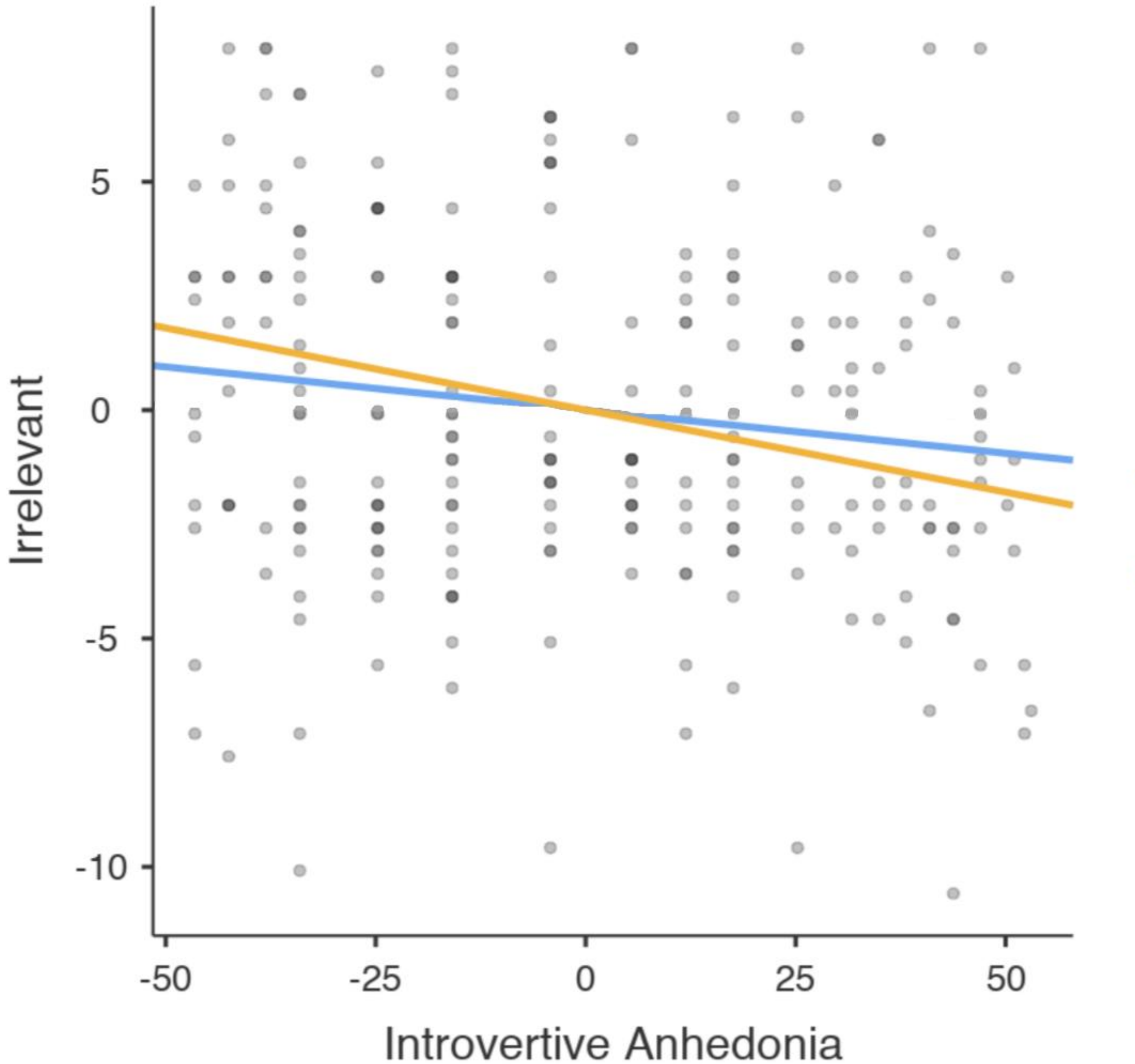


Figure 6.8: Simple slope plot illustrating the relationship between introvertive anhedonia and irrelevant stimuli in Study 7. Different coloured lines represent different levels of moderator. Grey line (low - -1SD) refers to the individualistic group, and the orange line (high - +1SD) refers to the collectivistic group.

D3: Summary of findings

There was evidence of extraversion positively predicting difference scores to the irrelevant stimuli and with further analysis, it was found that this effect was only in the collectivistic group; and was not previously observed in Study 5. There was also evidence of introvertive anhedonia negatively predicting differences score to the irrelevant stimuli and this was confirmed in the simple moderation analysis. This relationship was also not previously demonstrated in Study 5.

6.4: General Discussion

The first aim of this study was to provide an online replication of from Study 5 where learned predictiveness was found in the individualistic group but not the collectivistic group with a more sensitive means to measure cultural orientation. Next, it aimed to replicate the effects of conscientiousness on the degree of learning about previously relevant stimuli. This is because results from Study 5 revealed an effect of conscientiousness predicting learning of relevant stimuli, where participants high in conscientiousness from the individualistic group learned more about the relevant stimuli while participants from the collectivistic group showed less learning. Finally, it sought to determine if schizotypy plays a predicting role in learned predictiveness.

There was no difference found between learned predictiveness observed in an experiment conducted in a laboratory or as an online experiment. This suggests that learned predictiveness is a robust phenomenon that can be replicated online. This is not too surprising as in Study 6, latent inhibition was also replicated using an online task. This further validates online experimentation as a viable option to collect a large amount of data and especially for studies that require participants from different cultural backgrounds such as this current one.

To briefly reiterate the behavioural data, participants successfully learned the stimulus-outcome association in Stage 1 and 2. At the test stage, participants provided higher ratings to the relevant stimuli than the irrelevant stimuli, demonstrating a learned predictiveness effect, replicating Study 1 and 5; supporting the predictions made by traditional learning models such as the Mackintosh (1975) theory and hybrid models where the salience of a stimulus increases when it always predicts the same outcome. For example, in the Esber-Haselgrove (2010) hybrid model, the mechanism that drives this increase in salience is the net associative strength between the stimulus and outcome. And even though the irrelevant stimuli in this procedure were paired with two outcomes, the summed prediction error driving learning will ensure that the relevant stimuli would surpass the irrelevant stimuli for associative strength, see 1.11 for greater details.

A cluster analysis was conducted using the individualistic and collectivistic traits from the personal cultural orientation questionnaire to regroup the participants. It was found that 24.1% of participants in the individualistic group scored high in trait collectivism and 73.7% of participants in the collectivistic group scored high in trait individualism. The reason for these differences could be due to a variety of factors such as regional locations, socio-economic status and the influence of the mass media (Cohen, 2009; Kitayama and Uskul, 2011; Maisuwong, 2012).

When the data were analysed based on this grouping, there was no difference between the groups in learning during Stage 1 and 2. Consistent with Study 5, despite a lack of significance in the main effect of culture and interaction between culture and relevance of stimuli, as one of the aims of this study was to determine if there is a cultural differences in learned predictiveness as well as a replication of Study 5, a paired samples t-test was conducted and it revealed that learned predictiveness was demonstrated in the individualistic but not collectivistic group. These results thus validate the role of trait individualism in learned predictiveness; in other words, individuals high in trait individualism tend to learn more about the relevant stimuli as opposed to the irrelevant stimuli.

At the test stage, the numerical value of the ratings for all types of stimuli by the collectivistic group was higher than the individualistic group suggesting greater overall learning by the collectivistic group. There was also a significant difference between irrelevant stimuli ratings between the individualistic and collectivistic groups. One possible explanation for this learning bias towards irrelevant stimuli could be due to the writing systems normally associated with collectivistic cultures, such as the Chinese, Japanese and Korean languages. While it is unclear the number of participants who know these languages, based on their nationalities, 45% of participants in the collectivistic group are from China, Hong Kong and Malaysia, where at least one of these languages are learned by citizens (Chan and Wong, 2017; David, Dealwis and Hei, 2017; Hamdan and Ismail, 2019). Additionally, while there were some British participants who specified their heritage, there were 35% of British participants who did not, and therefore, it is possible for some of them to be of Asian descent and have learned these languages. In a learned predictiveness task, if a stimulus consistently predicts the same outcome, it is a good or relevant predictor, and if a stimulus predicts more than one outcome, it is a bad or irrelevant predictor. This classification assumes an elemental type of stimulus processing (Mackintosh, 1975) which as noted earlier, is consistent with the individualistic culture (Li et al., 2015; 2018). However, the configural type processing by the collectivistic culture (Nisbett et al., 2001) can be reflected in their writing systems which relies on a change surrounding a constant.

In Chinese, '马' means horse, if you add a mouth particle next to it '吗', it ends a sentence as a question, and if you add a female particle '妈', it becomes mother. In Japanese, the katakana character 'ハ' is pronounced as 'ha', 'バ' is pronounced as 'ba' and 'パ' is pronounced as 'pa'. [MH1] In Korean, '배', pronounced as 'bae' can mean belly, pear or boat. Only by adding a verb after it, '배 아프다' means belly ache, '배 먹고' means eat the pear, '배 타고' means ride the boat, would readers know which semantic meaning or pronunciation to use, see Table 6.6 for summary. One common thread between these languages is that there would be a 'root word' and when a particle, strokes or verb are added, do their inherent meaning change. A comparable example in the English language could be found in the word "bow". "Bow" if pronounced with a 'b-oh' sound, can refer to the instrument that shoots an arrow or the object held on the right hand used to play the violin. If it is pronounced with a 'b-a-o' sound, it would refer to the action of bending the head or upper part of the body.

Coming back to the learned predictiveness task, if apple + orange → nausea, and banana + orange → sweating, rather than classifying apple and banana as relevant and orange as irrelevant, participants may perceive orange as a constant (root word), the apple and bananas as identifiers (particles, strokes, verbs). For example, if orange is compounded with apple, the allergic reaction would be nausea. If orange is compounded with banana, the allergic reaction would be sweating. The orange, then, is entirely relevant to the task, and based on this we might anticipate that attention to this stimulus would be comparable in the collectivistic individuals. It can then be proposed that collectivistic participants' attention was mostly on the "irrelevant" stimuli, but their inherent thinking style and language background allowed them to also identify which stimuli was "relevant". This consequently biases learning of the irrelevant stimuli, and therefore warrants a further study using eye-tracking to determine the target of collectivistic participants' overt attention.

Table 6.9: Summary of how variations in particles, strokes and verbs can change the contextual meaning or pronunciation of words in Chinese, Japanese and Korean.

Language	Root word	Type of change	Meaning/Pronunciation
Chinese	马 means horse	Addition of mouth particle （口） - 吗	Ends sentence as a question
		Addition of female particle （女） - 妈	Mother
			*Incidentally, 马， 吗， 妈 are all pronounced as 'ma'
Japanese	ハ pronounced as 'ha'	Addition of double (`) at top right corner	バ pronounced as 'ba'
		Addition of (°) at top right corner	パ pronounced as 'pa'
Korean	배 is pronounced as 'bae' and can mean belly, pear or boat	Addition of the verb "to ache - 아프다"	배 아프다 - belly ache
		Addition of the verb "to eat - 먹고"	배 먹고 - eat a pear
		Addition of the verb "to ride - 타고"	배 타고 - ride a boat

The results of this study failed to replicate the effect of conscientiousness on learning about relevant stimuli. Instead, the findings from the correlation and regression indicated that extraversion positively predicts learning of the irrelevant stimuli in the individualistic group, but the simple moderation analysis revealed that this effect is found in the collectivistic and not the individualistic group. It is possible that this happened because the regression conducted in the collectivistic group was underpowered and therefore, did not show any significant relationship between extraversion and irrelevant stimuli but the simple moderation analysis was sensitive enough to detect this effect. This explanation is plausible as there was a strong evidence of introvertive anhedonia negatively predicting learning about the irrelevant stimuli in the collectivistic group was found, which reflects less learning about the irrelevant stimuli by collectivistic participants high in introvertive anhedonia. This is not really consistent with Haselgrove et al., (2016) who found less learning of *relevant* stimuli in those who score high in introvertive anhedonia.

According to different models of personality, extraversion and introversion are on the opposite ends of the same spectrum (Costa and McCrae, 2008; Eysenck, 1994). Someone who is an introvert tends to focus towards internal and subjective experiences while an extrovert is more objectively oriented and focuses more on actions than thoughts (Watson and Clark, 1997). Anhedonia refers to reduced motivation in anticipating, seeking and experiencing rewards (Silvia, Eddington, Harper, Burgin and Kwapil, 2020). Treadway, Bossaller, Shelton and Zaid (2012) found that not only were the patients with anhedonic symptoms less willing to spend effort in obtaining rewards, their ability to use information to guide their behaviour towards higher probability rewards were impaired. This is consistent with Bryant, Winer, Salem and Nadorff (2017) who found a debilitating effect of anhedonia on motivational levels in an individual, consequently impairing their drive to pursue rewarding goals. Their findings also revealed that if an individual is action-oriented and has low levels of anhedonia, they are able to upregulate positive affect in order to solve complex tasks. Based on this evidence, it can be assumed that extraversion and introvertive anhedonia are interrelated [10]. Hence, it could be argued that the effects of extraversion and introvertive anhedonia on the irrelevant stimuli are complementary. Hence, it is understandable that participants high in extraversion and consequently low in introvertive anhedonia would learn more about the irrelevant stimuli as they are motivated to do so.

The Wisconsin Card Sorting Task is comparable to a learned predictiveness task, the current result is somewhat consistent with Campbell et al., (2011) who found that participants high in extraversion perform better in the WCST than those low in extraversion. Participants in this current study low in introvertive anhedonia showed more learning of the irrelevant stimuli and this was not really consistent with Haselgrove et al. (2016), who found that participants low in introvertive anhedonia showed more learning of the relevant stimuli. Although, if we were to collectively look at the results from both the current study and Haselgrove et al., it could also be seen as somewhat complimentary in the sense that someone high in introvertive anhedonia would have a reduced motivation and seek rewarding goals (Silvia et al., 2020), and therefore would show overall reduced learning of all types of associations.

Footnote 10: Asai et al. (2015) found a relationship of extraversion negatively predicting introvertive anhedonia and this was relationship was replicated, see Appendix F.

In conclusion, there was no difference between the results obtained from a laboratory and an online task, validating the reliability of the food allergist task to generate learned predictiveness online. Furthermore, the effect of learned predictiveness demonstrated in the individualistic group but not in the collectivistic group that was observed in Experiment 7 was replicated. Importantly, this was accomplished when participants were grouped by their individual level of individualism and collectivism rather than by their nationalities. Lastly, when grouped by their trait cultural orientation, introvertive anhedonia negatively predicted learning about irrelevant stimuli, inconsistent with Haselgrove et al., (2016) results where introvertive anhedonia was found to be predicting less learning of relevant stimuli. Next, the effect of learned predictiveness demonstrated in the individualistic group but not in the collectivistic group was replicated, This was accomplished when participants were grouped by their individual level of individualism and collectivism rather than by their nationalities. Lastly, when grouped by their trait cultural orientation, introvertive anhedonia was negatively mediating the learning of irrelevant stimuli.

Chapter 7:

Thesis General Discussion

7.1: Overview

Associative learning phenomena have been used extensively to study the deficit of selective attention associated with schizophrenia. However, there has been a heavy focus on latent inhibition and relatively less focus on other effects such as blocking and learned predictiveness despite both these effects having been shown to be influenced by, and influencers of, attentional processes (Granger, Talwar and Barnett, 2020; Gray, Feldon, Rawlins, Hemsley and Smith, 1991, see Orosz, Cattapan-Ludewig, Gal and Feldon, 2008 for review). Research into impairments in attention in schizophrenia patients have been insightful but also ladened with inconsistencies due to the different symptoms exhibited by patients and their severity, the types of medication, prescribed or otherwise, they may have been taking as well as hospitalisation statuses (Baruch et al., 1988a; Cohen et al., 2004; Moran et al., 2008; Morris et al., 2013; Rascal et al., 2001; Serra et al., 2001). Therefore, schizotypy, a personality trait that mimics the symptomatology of schizophrenia, has been used as a proxy when conducting studies. Findings from schizotypy studies generally corroborate with those found in schizophrenia but there have also been inconsistencies like its schizophrenia counterpart (Evans et al., 2007; Granger et al., 2016; Haselgrove and Evans, 2010; Haselgrove et al., 2016; Humpston et al., 2017; Le Pelley et al., 2010). There has been an emphasis on utilising schizotypy in investigating the attenuation of attention-based learning; however, other personality traits such as anxiety and perhaps the most prominent in personality research, the Big 5, have been significantly overlooked. Moreover, cultural differences in learning and attention were also overlooked within the associative learning literature, despite there being a significant literature that points to their potential importance (Ji et al., 2000; Lehman et al., 2004; Nisbett et al., 2001; Norenzayan et al., 2002; Rhode et al., 2016)

This thesis therefore aimed to address these limitations and fill the gaps in the literature in the following ways. (1) By examining the relationship between different associative learning tasks in measuring learned attention - in order to address the inconsistencies found in the attenuation of learned attention in previous studies, this thesis aimed to determine if two associative learning effects can be found within the same individual in the hopes of comparing their magnitudes, and subsequently provide insights on a better measure of attention. (2) By determining which subscales of schizotypy are responsible for the impairments in learned attention – Furthermore, it aimed to identify how other personality traits, such as anxiety and the Big 5, play a role in these impairments found within the associative learning effects. (3) By investigating the extent to which cultural orientation (i.e., individualism and collectivism) moderate the allocation of attentional resources during learning and consequently determine the role they may play in associative learning.

This chapter will first provide a brief reiteration of the main results from the studies reported in this thesis. Next, it will discuss the different factors that can explain the results observed and highlight how this thesis addressed the limitations and gaps in the literature. It will then discuss the strengths and weaknesses of this thesis and future research based on the current findings will be presented.

7.2: Summary of findings

7.2.i: Studies 1-4 (Blocking and Learned Predictiveness)

As previously mentioned, latent inhibition has been widely used as an assay of learned attention and studies involving blocking and learned predictiveness have been relatively scarcer (see Chapter 2.5 and 2.6). Also, most studies have only tested individuals with one learning phenomenon itself and therefore, the first goal of Study 1 was to design a learning paradigm which can establish two learning effects within the same participant (blocking and learned predictiveness) by employing a food allergist task, and thus, be able to compare their magnitudes. If this hybrid task could generate both blocking and learned predictiveness, it could be used in further studies measuring personality traits and cultural differences. The results revealed that participants demonstrated learned predictiveness, where they rated the relevant stimuli greater than the irrelevant stimuli. However, there was no blocking observed as ratings for the "blocked" stimuli were, at least numerically, greater than the control stimuli. This is theoretically interesting as hybrid models of learning and attention (e.g., Esber and Haselgrove, 2011; Le Pelley; 2004; Pearce and Mackintosh, 2010) predict that there would be a stronger blocking effect compared to a learned predictiveness effect. This is because these models have multiple components within them to generate a blocking effect but, typically, only a single mechanism to generate learned predictiveness. For example, in Le Pelley's theory, the Mackintosh, Pearce-Hall and Rescorla-Wagner components of the model can all, independently, generate a blocking effect, whereas only the Mackintosh component can generate a learned predictiveness effect. The question then becomes, why, when an effect has so much explanatory redundancy for it within a model, is it comparatively difficult to observe?

Since this is the first time both learned predictiveness and blocking have been tested simultaneously, it was unclear whether the latter effect was, in some way, being masked by the former effect. Therefore, in Study 2, only the blocking design was conducted. Similar to findings from Study 1, participants provided numerically higher (but non-significantly higher) ratings for the "blocked" stimuli and lower ratings for the control stimuli. It was suggested that a within-compound association between the blocked and blocking stimuli may have precluded the observation of blocking by establishing an indirect associative chain to the outcome, an associative chain that would not be present in the control stimuli. Thus, Study 3 included an additional Stage 3, where the contingencies between the blocking and blocked stimuli were switched, see page 109-110 for details. However, the results still revealed a higher rating for the switched stimuli compared to control stimuli – providing little evidence for the role of within compound associations. A simplified version of the blocking design, more similar to that originally reported by Kamin (1969) was performed in Study 4 with the hopes of generating a blocking effect. While there was again no blocking effect, numerically, the ratings for the control stimuli were slightly higher than for the blocked stimuli. The findings from these studies were discussed in the context of the configural processing of compounds (Honey, Close and Lin, 2010) and the redundancy effect (Pearce et al., 2012; Zaksaite and Jones, 2020).

7.2.ii: Study 5 (Relationship between personality traits and cultural orientation in latent inhibition and learned predictiveness)

Since no blocking effect was observed in the four studies reported in chapter 3, study 5 employed another task that has been implicated in learned attention – latent inhibition; and investigated whether this phenomenon and learned predictiveness could be observed within the same individual. The letter prediction task (Granger et al., 2016) and food allergist task (Le Pelley and McLaren, 2003) were employed to generate latent inhibition and learned predictiveness respectively, and personality traits of schizotypy, anxiety and the Big 5 were also measured. In order to determine the cultural groups of participants, participants were sorted into individualistic and collectivistic groups using the Hofstede (2005) database. Initial analyses revealed that all participants demonstrated latent inhibition and learned predictiveness and these effects were not predicted by any of the personality traits. However, once the participants were split by culture, only the individualistic group showed latent inhibition and learned predictiveness. The collectivistic group, in contrast, only showed latent inhibition - learned predictiveness was attenuated in these participants. Study 5 also observed no correlation between latent inhibition and learned predictiveness. This is consistent with the predictions of the Esber-Haselgrove (2011) model, which proposes that the manner in which the associability of stimuli change during latent inhibition and learned predictiveness are determined by two different processes.

Study 5 also revealed that impulsive nonconformity positively predicted the magnitude of latent inhibition, but only in the individualistic group. There was also an effect of conscientiousness on the relevant stimuli, where participants in the individualistic group who were high in conscientiousness rated the relevant stimuli higher while participants in the collectivistic group high in conscientiousness would rate the relevant stimuli lower. There was no evidence of anxiety playing a role in latent inhibition or learned predictiveness.

7.2.iii: Study 6: Relationship between personality traits and cultural orientation in latent inhibition - An online replication

Study 6 was a replication of the latent inhibition task from Study 5, conducted as an online experiment. The results indicated that participants high in impulsive nonconformity showed enhanced latent inhibition. This predicting effect of impulsive nonconformity was only found in latent inhibition score and not in the preexposed and non-preexposed reaction times, and only in the individualistic group. Therefore, a replication is necessary as there has not been a study previously conducted investigating the cultural differences in schizotypy predicting latent inhibition.

Participants from both individualistic and collectivistic cultures both showed latent inhibition – to a comparable degree, and furthermore there was no difference between the magnitude of latent inhibition obtained from the online study 6 and a lab-based experiment reported in study 5. The effect of impulsive nonconformity was, however, not replicated. The results showed that participants from the individualistic group who were high in conscientiousness were slower to react to the non-preexposed cues and showed reduced latent inhibition. Also, participants from the collectivistic group who were high in openness demonstrated enhanced latent inhibition. There was, again, no evidence of anxiety playing a role in latent inhibition.

7.2.iv: Study 7: Relationship between personality traits and cultural orientation in learned predictiveness - An online replication

Study 7 was a replication of the learned predictiveness task reported in Study 5 but with a more sensitive measure of cultural orientation. Classifying individuals by nationalities has been shown to have limitations as there are various external factors such as socio-economic status (Kitayama and Uskul, 2011), geographical locations (Cohen, 2009) and influence of media (Maisuwong, 2012). Initial analysis revealed that all participants demonstrated a learned predictiveness effect. However, when participants were grouped by trait individualism and collectivism, despite not observing a significant main effect of culture and interaction effect between culture and relevance of stimuli, only the individualistic group showed a learned predictiveness effect, replicating Study 5. Furthermore, there was a bias of learning about the irrelevant stimuli seen in the collectivistic group. The effect observed in Study 5 of participants high in conscientiousness from the individualistic group providing higher ratings to the relevant stimuli and those from the collectivistic group providing lower ratings to the relevant stimuli was not replicated. Instead, participants high in extraversion from the collectivistic group providing higher ratings for the irrelevant stimuli were found. Moreover, participants in the collectivistic group high in introvertive anhedonia showed less learning about the irrelevant stimuli.

7.2.v: Summary

To summarise, as can be seen in both Studies 5 and 6, latent inhibition can be found in both cultures regardless of the study being lab-based or online. As can be seen in both Studies 5 and 7, while learned predictiveness can be found regardless of the study being lab-based or online, the results consistently show that learned predictiveness can only be found in the individualistic group and not in the collectivistic group even though there was no significant main effect of culture and interaction effect between culture and relevance of stimuli. Despite the previous literature supporting an effect of anxiety playing a role in the disruption of attentional learning (Braunstein-Bercovitz et al., 2000, 2001), Studies 5 and 6 did not find any effect of anxiety on latent inhibition and learned predictiveness. With regards to the Big 5 and schizotypy, the studies reported in this thesis showed no consistent pattern of how these personality traits play a role in latent inhibition and learned predictiveness, further replication of these studies should be conducted as these studies were essentially one of the first that investigate individual and cultural differences within attentional learning at a relatively large-scale.

7.3: Elemental/analytical and configural/holistic processing

The first goal of this thesis was to generate two different types of associative learning phenomena within the same individual. When learned predictiveness and blocking were tested within a single paradigm, only learned predictiveness could be observed. When latent inhibition and learned predictiveness were tested, only the individualistic group consistently demonstrated both learned predictiveness and latent inhibition, while the collectivistic group only demonstrated latent inhibition. One possible reason for why it is difficult to reproduce learned predictiveness and blocking, particularly in participants from a collectivistic culture, is due to differences in elemental and configural processing of compound stimuli.

In a review, Melchers, Shanks and Lachnit (2008) suggested that some associative learning tasks can be solved either elementally or configurally. According to the Replaced Elements Model, this flexibility in processing is contingent on the similarity of the stimuli, where stimuli with high similarity (from the same modality) encourage configural processing while stimuli with low similarity (from different modalities) encourage elemental processing (Wagner, 2003). Elemental and configural processing can be influenced by prior experience, stimulus properties and stimulus organization (Melchers et al., 2007) but it is unknown whether divergent thinking biases and mental representations shown in individualistic and collectivistic cultures play a role in associative learning tasks. Within the Replaced Elements Model, Wagner (2003) proposed a continuum of elementality to configuration called r, where r represents the proportion of elements representing a stimulus being replaced. When the stimuli are compounded from the same modality, it was proposed that the r value is high and when the stimuli is compounded from different modalities, it was proposed that the r value is low. It could be hypothesized that individualism and collectivism which can also be measured on a continuum be compared to this r continuum, where individualistic participants have a relatively low r while collectivistic participants have a relatively high r. On this basis, then, individualistic participants would be expected to demonstrate effects like blocking and learned predictiveness as the representation of the stimuli, will be the same, or very similar, irrespective of the context that they are in. Thus, a blocking stimulus will carry over its associative strength into Stage 2 from Stage 1, and permit cue competition; and relevant and irrelevant stimuli will carry over their differences in attention into Stage 2 from Stage 1 and bias learning about O3 and O4. In contrast, participants in collectivistic cultures, who are hypothesised to have a higher r, will show an attenuation in both blocking and learned predictiveness as the context changes for the stimuli between Stage 1 and Stage 2, thus encouraging replacement.

It is possible that latent inhibition is simply a very straightforward effect to generate with the current procedure and will be observed irrespective of the various potential cultural or personality-based variables that might interfere with it. That is to say, we are observing a ceiling effect. Consistent with this proposal is the observation that we can obtain latent inhibition, using the current procedure, in children as young as 4 years old, see Appendix E. In contrast, learned predictiveness may require more conditions to observe. However, it is proposed that an explanation for the difference between these learned predictiveness and latent inhibition is in the nature of the mode of stimulus presentation. The letter prediction task used to produce latent inhibition involves presenting the preexposed cue one at a time and in the later test stage, the preexposed and non-preexposed cues were also individually presented, followed by the target stimulus. As there are no compounds throughout the task, there is no contextual change for replacement to have an impact upon, which could be why both culture groups demonstrate latent inhibition.

The dominant analysis of learned predictiveness comes from an elemental processing perspective (e.g., Esber and Haselgrove, 2011; Mackintosh, 1975; Le Pelley, 2004; Pearce and Hall, but see: George and Pearce, 2012) in which the representation of the items of association occurs at the stimulus, rather than the compound level. Therefore, participants in the individualistic group, who have a tendency to think analytically, can easily learn to distinguish the relevant stimuli from the irrelevant stimuli and hence produce learned predictiveness. This, however, does not mean that the collectivistic group did not learn to differentiate between both types of cues and in turn, learn them both equally as well. In fact, there were no group differences in the ratings provided for the relevant stimuli for both studies. Also, even though there was no statistical significance except for the irrelevant stimuli, the mean ratings provided by the collectivistic group were higher than the individualistic stimuli for all types of stimuli in Study 7. Similarly, with blocking, elemental theories (e.g., Rescorla-Wagner, 1972, Mackintosh, 1975) predict a blocking effect but configural theories (Honey et al., 2010; Pearce, 1994) predict either a weak or no blocking effect. While the failure to obtain blocking in Chapter 3 can be explained with the redundancy effect and acquired equivalence, it is also possible that participants had a tendency to think configurally. However, this series of studies did not collect information related to participants' nationalities and neither were they asked to complete a cultural orientation questionnaire, and thus, we are unable to make further inferences on this point.

Regardless, findings from these studies seem to suggest that the prevailing elemental theories and models that can explain learned predictiveness and blocking are only applicable for participants from an individualistic culture and not from a collectivistic one, although this cannot be confidently stated as there was no significant main effect of culture and interaction effect between relevance of stimuli and individualism/collectivism. Still, this is problematic as learning theories and models are derived to understand the mechanisms that underlie learning should not be only valid for one culture - or indeed one species, as they are inspired from a history of experimentation into animal learning and conditioning. On the other hand, even though the Honey network (Honey et al., 2010) is a configural network that can explain learned predictiveness via acquired distinctiveness, it does not predict blocking. While the Replaced Elements Model (Wagner, 2003) can explain the flexibility in switching between elemental and configural processing, it is dependent on the nature of the CS and does not account for a predisposition a participant would have on types of processing. Future experiments will be key to understanding this conceptualisation of stimulus representation in individualistic and collectivistic cultures.

This said, perhaps the Esber-Haselgrove (2011) hybrid approach is also an encouraging theory with which to consolidate the differences in types of processing participants from different cultures are showing. In this model, acquired salience of a cue (ε) is a function of the sum of its associations with outcomes. If this function is removed, learning would still progress normally but attention to a cue would not be changed. In a sense, it is possible that the tendency to think elementally or configurally by individualistic and collectivistic group respectively, moderate this function whereby the collectivistic group's predisposition to think configurally boosts overall learning of all cue types, including the irrelevant stimuli. whereas the predisposition to think elementally and hence, only focus on the relevant stimuli and not the irrelevant stimuli by the individualistic group would explain the consistent learned predictiveness effect shown by individualistic participants.

7.4: Role of language in attention allocation

Human language acts as a carrier of cultural information because it has the ability to express a substantial number of concepts (for review, see Cornish, 2011). However, relatively few studies have been conducted to determine to what extent it may affect attention and information processing. Languages like English and Chinese have a deep orthography (i.e., *indirect* association between phoneme (sound) and grapheme (letters) while languages like Japanese and Korean have shallow orthographies (*direct* association between phoneme (sound) and grapheme (letters)), see Katz and Frost, 1992 for review. Rhode, Voyer and Gleibs (2016) proposed that habits formed from language use can transfer to non-linguistic settings. The deep orthography of English requires users to decode each syllable individually to understand a word, which may have led users to be object-oriented and think elementally. Meanwhile, the shallow orthography of Japanese and Korean allows users to immediately pronounce what is being spelt but because a word can be made up from several syllables, users have to process all the syllables to obtain a semantic meaning. This may contribute to why Japanese and Korean nationals have a tendency to think configurally (Rhode et al., 2016). Importantly, the degree of holistic processing shown in nations typically grouped as collectivistic (China, Japan and Korea) has been found to vary as a function of how their language is structured (Tajima and Duffield, 2012) which is consistent with the Chinese language also having a deep orthographic system. There are two components to the Chinese language: logographic and phonetic. The former provides a visual cue to the semantic meaning while the latter provides a partial guidance on the pronunciation of the word (Katz and Frost, 1992), and a combination of both makes a unique spoken character. Similar to Japanese and Korean, a word in Chinese can be made up of multiple characters. On the basis of this analysis, it can be inferred that a user of Chinese would be equally as skilled in elemental and configural processing.

Relating back to the current thesis, if an individual is a Chinese user, it could be proposed that they would have an advantage in general in learning about the relationships between stimuli compared to someone who is not. However, it is unknown to what extent would they be better than someone who uses a language with purely deep orthography (English) in elemental thinking/learning; and better than someone who uses a language with purely shallow orthography (Korean and Japanese) in configural thinking/learning is difficult to establish. This is because i) the studies conducted in this thesis did not conduct a language background questionnaire and ii) while there are some Chinese nationals within the sample, due to the relatively low number of participants, it is difficult to be confident about any impact of the contribution of national language to latent inhibition and learned predictiveness.

7.5: Role of personality traits in learning

Even though the Big 5 personality traits are one of the most prominent and well-researched personality models, very little work has been conducted with regards to their impact upon associative learning and attention. The findings from the studies conducted reveal that openness, conscientiousness and extraversion play a role in learned predictiveness and latent inhibition. DeYoung (2015) introduced a cybernetic model where he superimposed two meta-traits, plasticity and stability, onto the Big 5 personality traits. Plasticity consists of extraversion and openness/intellect [11], which is concerned with “exploration…, creation of new goals, interpretation and strategies”. Stability consists of conscientiousness, agreeableness and neuroticism, and is concerned with “protection of goals…, interpretations and strategies from disruption by impulses”. Individually, he defines extraversion with “behavioural exploration and engagement with specific rewards”; openness/intellect with “cognitive exploration and engagement with information”; and conscientiousness with “protection of non-immediate or abstract goals and strategies from disruption”. In other words, extraversion modulates motivational drive and Robinson, Moeller and Ode (2010) found that participants high in extraversion show better learning where rewards were given in reinforcement learning paradigms. Also, Campbell et al. (2011) demonstrated that extraversion predicted better performance in the Wisconsin Card Sorting Task. Hence, even though the irrelevant stimuli were not of importance, participants high in extraversion would tend to learn more about it compared to those who are low in extraversion.

Footnote 11: In this model, DeYoung collapsed both openness and intellect traits into one low-level trait, see DeYoung (2015) for more details.

With regards to latent inhibition, DeYoung (2014) described someone high in openness as someone with a tendency to engage in novel and interesting phenomena, and therefore, as a culture who is sensitive to covariations in context (Ji et al., 2000). On the basis of this we might expect that participants high in this personality dimension detect the non-preexposed cues quicker and therefore, show enhanced latent inhibition, which is consistent with our findings. Based on DeYoung's description of this model, it could be argued that conscientiousness is related to appropriate allocation of attentional resources by suppressing non-essential disruptions. This is consistent with the results obtained in Study 5, where participants in the individualistic group focussed on the relevant stimuli, consequently providing higher ratings compared to the irrelevant stimuli. As seen from Li et al. (2018), participants from collectivistic cultures are slightly more liberal in assigning resources, where a majority of resources will be placed at the focal points of attack in an “attack-the-fort” game, but some of the resources will be placed on other possible points of attack of the fort, consistent with a holistic view of the world. Thus, participants from the collectivistic group high in conscientiousness may be expected to attend more towards the relevant stimuli but at the same time pay attention to the irrelevant stimuli, therefore, demonstrating no learned predictiveness. Furthermore, since conscientiousness is associated with impulse inhibition (DeYoung, 2015), it is consistent with the slower non-preexposed cues reaction times in the letter prediction task leading to a reduced latent inhibition in Study 6, and retarded learning of relevant stimuli in Study 7.

7.6: Plasticity and Psychopathology

Plasticity refers to an individual's predisposition for cognitive exploration, where openness and extraversion complement each other in setting a goal and determining what is the best approach in attaining it (DeYoung, 2015). Furthermore, openness has been found to positively predict unusual experiences and extraversion has been found to negatively predict introvertive anhedonia (Asai et al., 2015). Both unusual experiences and introvertive anhedonia have also been associated with impaired learned predictiveness and latent inhibition (Granger et al., 2016; Granger and Young, 2012; Gray et al., 2002; Haselgrove et al., 2016; Le Pelley et al., 2010).

Positive schizotypy or psychoticism has been connected to openness but only if it is separated from the intellect trait (Chmielewski, Bagby, Markon, Ring and Ryder, 2014; DeYoung, Grazioplene and Peterson, 2012). In this case, the cybernetic model associates openness with a system that detects patterns automatically and intellect with a system that determines whether the patterns detected are true or false. Therefore, if one is high in openness but low in intellect (crystallised intelligence), they are more susceptible to monitoring errors or reality and may experience hallucinations and delusions consistent with positive schizotypy. However, a high level of intellect would compensate for openness to reduce this tendency. This supports previous studies (Evans et al., 2007; Gray et al., 2002; Peterson and Carson, 2000) which found that high levels of unusual experiences and openness impair latent inhibition, but high levels of openness in the collectivistic group in Study 6 did not impair latent inhibition. This could be due to the fact that participants who show this effect are also high in intellect which compensated for the possibility of openness disrupting latent inhibition as seen in Peterson and Carson (2000). This suggests that intellect might play a bigger role in attentional learning than previously considered.

7.7: Strengths and implications

7.7.i: Online experiments

Due to the Covid-19 global pandemic, all data collection for studies 6 and 7 had to be conducted online and consequently, the tasks used in this thesis (the letter prediction task and the food allergist task) were the firsts to be used to explore whether learned predictiveness and latent inhibition could be obtained online. Findings from Study 6 and 7 have shown that both latent inhibition and learned predictiveness are robust enough to be generated in a remote location and online setting and therefore, provides evidence for reliability and validity of online testing.

Even without the pandemic, online testing has been typically favourable for researchers who require a large sample size and access to a wide demographic within a short amount of time (Crump et al., 2013). However, one of the main challenges is the researcher having the necessary skills to be able to programme an online experiment as well as for it to be compatible on various devices. Fortunately, research software such as PsychoPy provides users the flexibility to program experiments without needing much knowledge in coding and has a feature to upload the task to be conducted online. Another concern relating to online testing is the accuracy of stimulus presentation and the precision of response timing. Bridges, Pitiot, MacAskill and Peirce (2020) compared various popular research software packages and found that for online studies, PsychoPy and Gorilla showed the best overall performance across several browsers running on various operating systems, and PsychoPy showed the highest precision for response times, which was measured using a high-performance button box.

Moreover, PsychoPy is free to use and while running experiments on their online counterpart (Pavlovia) requires a small fee, an institution license at an affordable price is available and this license allows all researchers from the same institution to collect data without having to purchase their own credits. This is advantageous as hosting studies on platforms such as MTurk and Prolific can get expensive over a long period of time and if a large number of participants is needed. Finally, as PsychoPy is open-sourced, experimental tasks can be easily shared, and this can be a cheap alternative to researchers and practitioners who may need to pay third-party services per task.

7.7.ii: Clinical applications

A key theory of deficits in attention emphasizes the role of a hyperdopaminergic condition leading to a state of aberrant salience, which in turn results in an inability to discriminate between relevant and irrelevant stimuli (Kapur, 2003). Dopamine is regarded to be a key neuroregulator responsible for adaptation of behaviour and anticipatory processes crucial for preparing intentional voluntary action (Nieoullon, 2002). Thus, it is possible that a disruption in the dopaminergic system may lead to a disruption in selective attention. Dopamine has been implicated with extraversion (Depue and Collins, 1999) and reward sensitivity in humans (DeYoung, 2013). DeYoung (2014) thus suggests that high levels of dopamine would influence exploratory motivation, a key feature of extraversion. Low levels of dopamine have also been associated with major depression, which includes reduced motivation, concentration and ability to experience pleasure (Dunlop and Nemeroff, 2007), and this mirrors introvertive anhedonia. Hence, while it is known that extraversion and introversion are opposites, it would be of interest to determine to what extent extraversion is the antagonist of anhedonia, and this will be elaborated in the next section of this chapter.

7.8: Limitations and future directions

As just seen from the end of the previous section, introvertive anhedonia can be divided into two further subtraits, introversion and anhedonia. While extraversion and introversion are commonly recognised as being on the opposite sides of a spectrum, it is unclear whether anhedonia independent of introversion is as well. Anhedonia refers to the inability to experience pleasure and has been associated with impairments in learning or forming predictions (see Langvik and Borgen Austad, 2019 for review). Thus, a future study can include a questionnaire that measures trait anhedonia, like the Snaith-Hamilton Pleasure Scale (Snaith, Hamilton, Morley, Humayan, Hargreaves and Trigwell, 1995) alongside the Big 5 and OLIFE questionnaire to provide a clearer picture of the relationship between extraversion and trait anhedonia.

To briefly reiterate, in Section 7.4, it was suggested that users of the Chinese language would be equally as skilled in elemental and configural processing compared to users of English who would have an advantage in elemental processing and users of Korean/Japanese who would have an advantage in configural processing. Therefore, a further study could be conducted where the experimental procedure used in Study 5, where participants took part in both the learned predictiveness and latent inhibition task could be replicated. To measure individualism and collectivism, participants' nationalities will be recorded, and the personal cultural orientation questionnaire will also be conducted. Additionally, a language background questionnaire will also be given to determine if fluency or being bilingual would have an effect on elemental/configural processing.

Both individualistic and collectivistic groups demonstrated a latent inhibition effect with the letter prediction task, which suggests that both groups can process single stimulus associations. If the reason why the collectivistic group cannot demonstrate learned predictiveness is because of their tendency to think configurally, thus, learning both relevant and irrelevant stimuli equally during training, then a further study using a single cue learned predictiveness task (Le Pelley, Turnbull, Reimers and Knipe, 2010) can be employed. In this task, the outcome would consistently be predicted by the same cue, consistently presented in isolation. On this basis, any biases towards collectivistic/configural thinking would not disrupt performance (Lee, 2017; Nisbett, 2001). Furthermore, future research should include conducting a biconditional discrimination task. In a typical biconditional discrimination design (AX+, AY-, BX-, BY+), none of the individual stimulus predicts the outcome and consequently, they cannot be used by themselves to solve the discrimination. This essentially forces participants to learn the compound stimuli configurally and it can be predicted that the collectivistic group will be better in solving the task compared to the individualistic group due to their predisposition in configural thinking style.

It would also be of interest to conduct a compound stimuli latent inhibition study. By slightly modifying the letter prediction task, instead of singly preexposed, non-preexposed and filler letters, they could be presented in compounds. For example, In the first group, participants will be exposed to AX and BY while in the second group, participants will be exposed to AB and XY. In the test stage, participants will be presented with AB+ and XY+. If a latent inhibition effect is to be found, it is hypothesised that it will be in Group 2 as it is predicted that participants in Group 2 will be slower to respond to AB+ and XY+ compared to Group 1 because the former was preexposed to the compounds and the latter was not.

Findings from Study 6 revealed that participants from the collectivistic group high in openness showed enhanced latent inhibition which is inconsistent with previous studies (Peterson et al., 2000, 2002). However, as highlighted in Section 7.6, openness can sometimes be viewed as two separate traits: openness and intellect, and while previous literature has shown that openness disrupts latent inhibition, a high level of intellect can help offset this effect, thus showing enhanced latent inhibition. Future studies should include a working memory task such as in (DeYoung, Shamosh, Green, Braver and Gray, 2009) that is capable of separating intellect from openness in conjunction with an attentional learning task while also measuring the Big 5 personality traits to determine the extent of the role of intellect. Moreover, openness has been associated with unusual experiences (Asai et al., 2015) and unusual experiences have been associated with enhanced latent inhibition (Granger et al., 2016) but the authors of this paper did not include a measurement of individualism and collectivism. Therefore, a future study can be conducted with a cultural orientation questionnaire (Sharma, 2010) to replicate these findings.

Despite conducting Study 6 and 7 as a replication of Study 5, the relationships between the personality traits and latent inhibition/learned predictiveness are mixed. While one could argue that the context of testing may have played a role in the inconsistent findings, a between subjects t-test (lab vs online) was conducted comparing the total scores of each personality trait of the Big 5 and OLIFE was the only trait that had a significant difference was extraversion (lab: M = 40.94, SEM = 0.60; online: M = 38.46, SEM = 0.52, N_{lab} = 263, N_{online} = 378). Although, this drop in extraversion levels could just be that when the online experiment was conducted, most countries in the world were under lockdown which may have impacted on the extraversion levels of individuals. This does however bring the question of the replicability of these relationships, which can be mitigated by the Bayes factor that provides the community with a way of understanding their relative importance.

7.9: Conclusions

This thesis aimed to consolidate the inconsistencies in the associative learning and schizotypy literature by attempting to reproduce two learning phenomena within the same individual and establish a better measure of attention. While blocking could not be reproduced throughout Study 1 to 4, Study 5 successfully reproduced latent inhibition and learned predictiveness. However, it appears that only the individualistic group showed both effects while the collectivistic group only demonstrated latent inhibition. This finding was explained using the different thinking styles of individualistic and collectivistic cultures. Furthermore, this thesis also filled the knowledge gap between the Big 5 and schizotypy, and latent inhibition and learned predictiveness, but found no role of anxiety in both effects, see Table 7.1 for a summary of these findings. As can be seen from Table 7.1, we can consistently demonstrate latent inhibition in both culture groups and despite no significant main effect of culture and interaction effect between relevance of stimuli and culture, the effect of learned predictiveness seems to be only demonstrated in the individualistic group; the findings with regards to personality traits are not entirely consistent. This thesis aimed to clarify the puzzlingly relationship between schizotypy and learning but unfortunately, it failed to resolve the ambiguous existing literature. There is however some optimism with the Big 5 personality traits. The meta-traits, plasticity and stability, within the cybernetic model of the Big 5 have been used to account for the effects of openness, extraversion and conscientiousness shown when predicting learning of relevant and irrelevant stimuli.

Table 7.1: Summary of individual and cultural differences in results across Study 5, 6 and 7.

	Study 5	Study 6	Study 7
Summary of findings	- Both individualistic and collectivistic groups demonstrated latent inhibition. - Learned predictiveness was only demonstrated in the individualistic group but not the collectivistic group, despite lack of significant main effect of culture and interaction effect between culture and relevance of stimuli - An effect of **conscientiousness** predicting higher ratings for relevant stimuli in individualistic group and lower ratings for relevant stimuli in collectivistic group - An effect of **impulsive nonconformity** in predicting enhanced latent	- Replicated latent inhibition demonstrated in both individualistic and collectivistic group. - Anecdotal evidence of **conscientiousness** predicting slower learning of NPE and smaller magnitude of latent inhibition in the individualistic group - Anecdotal evidence of **openness** predicting larger magnitude of latent inhibition in collectivistic group - No effect of schizotypy and anxiety	- Replicated learned predictiveness only demonstrated in individualistic but not collectivistic group, even though there was no significant main effect of culture and interaction effect between culture and relevance of stimuli - An effect of **extraversion** positively predicting higher ratings for irrelevant stimuli only in collectivistic group - An effect of **introvertive anhedonia** negatively predicting ratings for

	inhibition only in the individualistic group - No effect of anxiety	irrelevant stimuli only in collectivistic group

This thesis has also discussed the various reasons why levels of individualism and collectivism can differ may not only be based on nationalities but by other internal (language) and external (geographical locations, socio-economic status and exposure to media) factors, and these have been discussed in relation to the results obtained in this thesis. The effect of introvertive anhedonia on irrelevant stimuli is thought to be complementary to the effect of extraversion and its clinical implications with dopamine was also discussed.

In conclusion, the findings of this thesis provided further empirical evidence for the Esber-Haselgrove (2011) model as well as the cybernetic model of the Big 5 personality traits (DeYoung, 2015). It has also filled many knowledge gaps with regards to individual differences in attentional learning, but most importantly, opened the door to considering cultural aspects that can also affect attention-based learning. Many formalised associative learning models have been introduced to describe and explain the different learning phenomena and while hybrid models can adequately explain them, the predisposition to think/learn elementally or configurally that is influenced by individualism/collectivism provides a fascinating future direction to study attentional learning.

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Appendix A

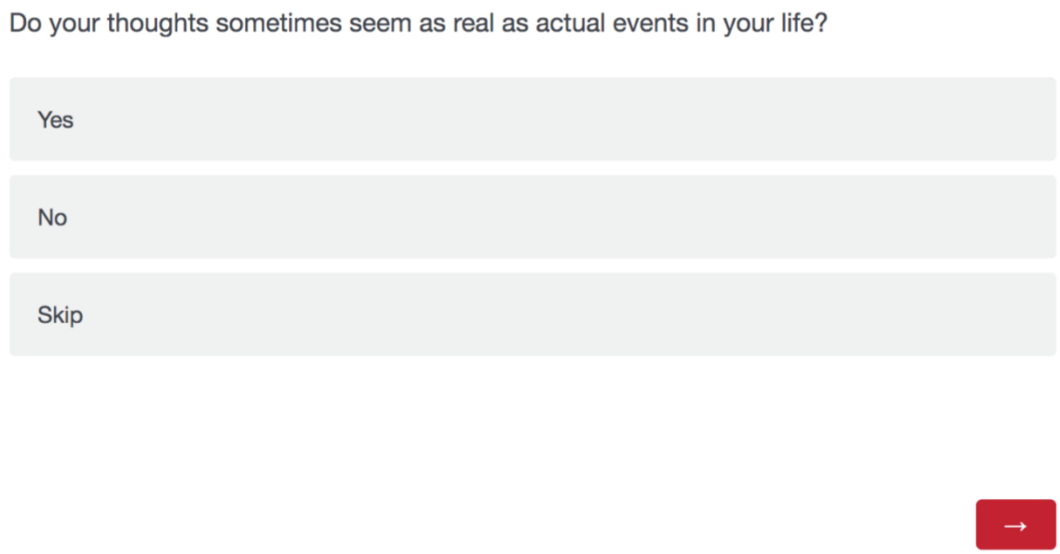
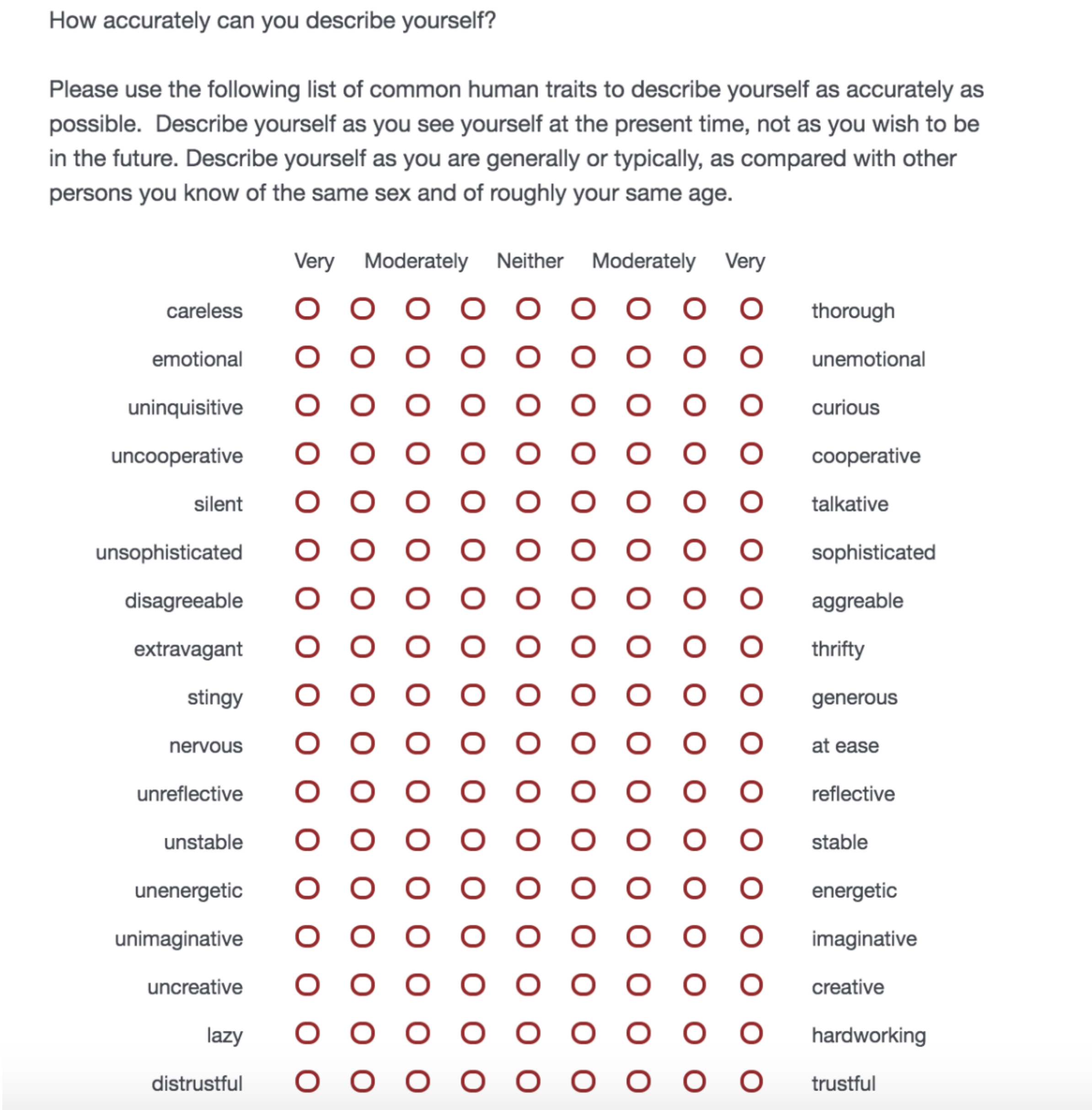


Figure A.1: Screenshot of example questions in the O-LIFE questionnaire

Appendix B


How accurately can you describe yourself?

Please use the following list of common human traits to describe yourself as accurately as possible. Describe yourself as you see yourself at the present time, not as you wish to be in the future. Describe yourself as you are generally or typically, as compared with other persons you know of the same sex and of roughly your same age.

	Very	Moderately	Neither	Moderately	Very	
careless						thorough
emotional						unemotional
uninquisitive						curious
uncooperative						cooperative
silent						talkative
unsophisticated						sophisticated
disagreeable						aggreable
extravagant						thrifty
stingy						generous
nervous						at ease
unreflective						reflective
unstable						stable
unenergetic						energetic
unimaginative						imaginative
uncreative						creative
lazy						hardworking
distrustful						trustful

Figure B.1: Screenshot of example questions in the Big 5 questionnaire

Appendix C

Below is a list of statements which can be used to describe how people feel.

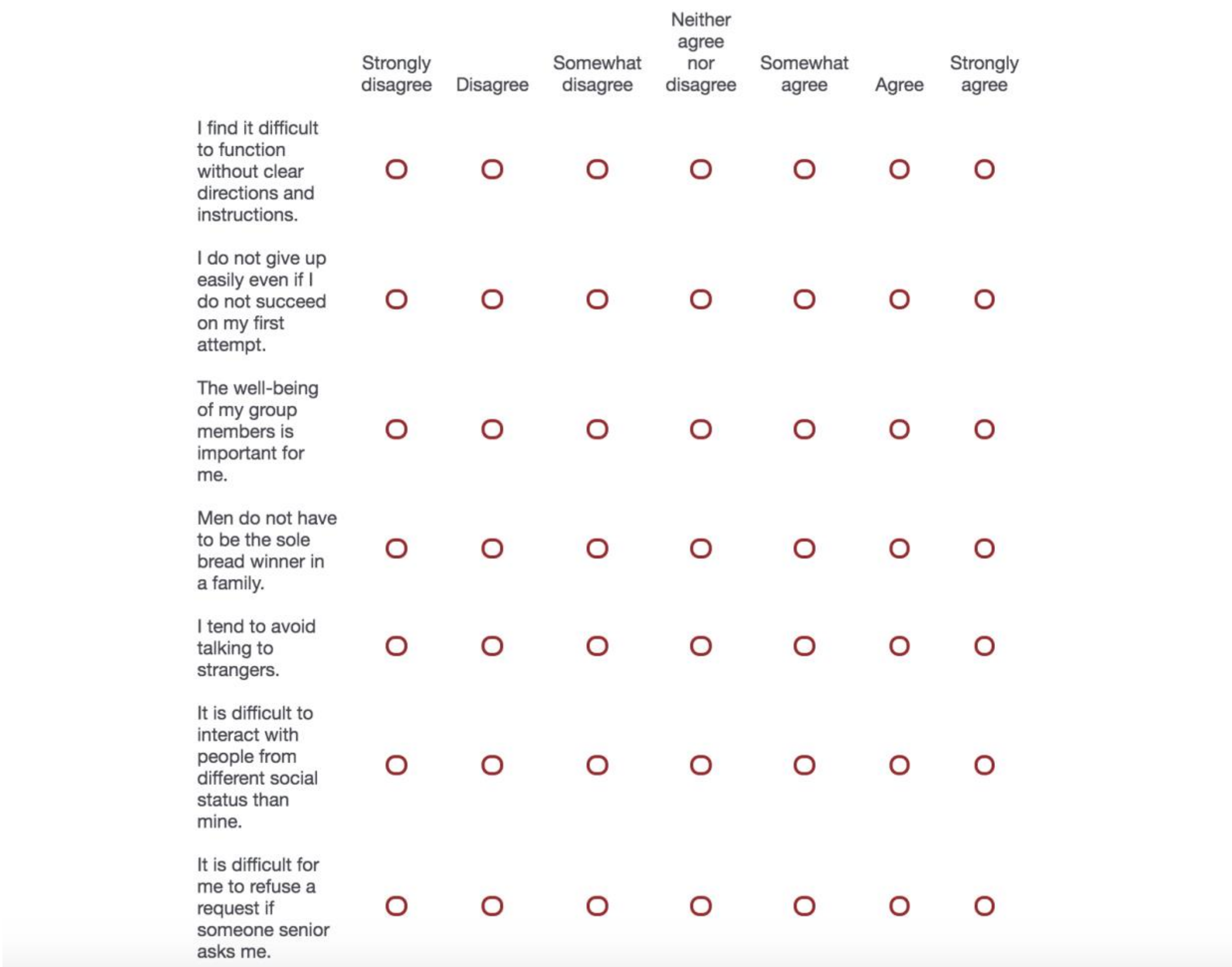
Next to each statement are four descriptors which indicate the degree with each statement is self-descriptive of mood AT THIS MOMENT.

Please read each statement carefully and choose the descriptor which best indicates HOW YOU FEEL RIGHT NOW, at this very moment, even if this is not how you usually feel.

	Not at all	A little	Moderately	Very much so
I feel trembly and shaky.	O	O	O	O
I have trouble remembering things.	O	O	O	O
My heart beats fast.	O	O	O	O
I feel dizzy.	O	O	O	O
My muscles feel weak.	O	O	O	O
I can’t get some thought out of my mind.	O	O	O	O
I think that the worst will happen.	O	O	O	O
My arms and legs feel stiff.	O	O	O	O
My breathing is fast and shallow.	O	O	O	O
I feel like I’m missing out on things because I can’t make up my mind soon enough.	O	O	O	O
I picture some future misfortune.	O	O	O	O

Figure C.1: Screenshot of example questions in the STICSA questionnaire

Appendix D



	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I find it difficult to function without clear directions and instructions.	O	O	O	O	O	O	O
I do not give up easily even if I do not succeed on my first attempt.	O	O	O	O	O	O	O
The well-being of my group members is important for me.	O	O	O	O	O	O	O
Men do not have to be the sole bread winner in a family.	O	O	O	O	O	O	O
I tend to avoid talking to strangers.	O	O	O	O	O	O	O
It is difficult to interact with people from different social status than mine.	O	O	O	O	O	O	O
It is difficult for me to refuse a request if someone senior asks me.	O	O	O	O	O	O	O

Figure D.1: Screenshot of example questions in the personal cultural orientation questionnaire

Appendix E: Latent Inhibition in Children

E1: Introduction

Latent inhibition refers to the retardation in subsequent conditioning when the CS is paired with a US following the presentation of that CS by itself (Lubow & Moore, 1959). It is a reliable phenomenon that has been demonstrated in a variety of species, for example, in goats and sheep (Lubow & Moore, 1959), rats (Kaye & Pearce, 1987). While it can also be found in humans, there have been challenges in testing a pure latent inhibition effect (see Byrom, Msetfi & Murphy, 2018 for review).

Cantor (1969) found that simply pre-exposing children to light is sufficient in response times to that same light in young children, and Lubow, Alek & Arzy (1975) replicated the same effect in children but not in adults. Lubow, Rifkin & Alek (1976) preexposed two groups of 5 year olds to five objects of different shapes and colours. During the test stage, half of each group were presented with the preexposed objects and the other half were presented with novel objects. The children were tasked to associate a reinforcement (marble) with one of the objects in the test stage and found that the group that were presented with the preexposed objects showed more errors and were slower to reach criterion compared to the group that was tested with novel objects.

Kaniel & Lubow (1986) was interested in establishing a development curve of latent inhibition and therefore had children from 2 age groups of children: 4-5 year olds and 8-11 year olds. Figure E1.1 shows an illustration of their design.

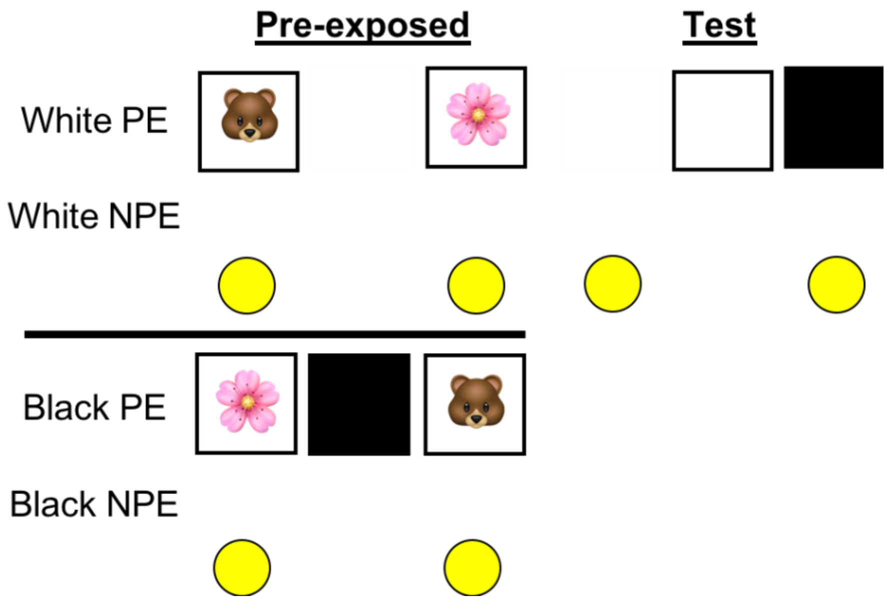


Figure E1.1: Interpreted illustration of Kaniel & Lubow (1986) design. In the preexposed stage, the animal and plant were the response stimuli while the black and white squares were the preexposed stimuli. There were two buttons (yellow circles) for the children to use to respond. The test stage had two conditions, white and black, where in the white condition, white squares would always be the correct answer, and in the black condition, black would always be the correct answer.

In the preexposure stage, children were presented with three squares, either a black or white square (preexposed stimuli) and they were flanked by a picture of an animal and plant. There were four groups of children: i) preexposed to white; ii) not preexposed to white; iii) preexposed to black; iv) not preexposed to black. Children had to respond to either the plant or animal and the younger children were rewarded with a marble while the older children were rewarded verbally. In the test stage, the black and white squares were now on the left and right and children had to respond to them. The results revealed that children ages 4-5 who were in the not preexposed group learned the correct answer quicker than the group that was preexposed, and the older children (8-

11 year olds) showed no difference. So far, the evidence shows that latent inhibition can only be seen in younger children but not older ones. However, Lubow, Caspy & Schnur (1982) found that latent inhibition can be found in 10-11 year olds if a masking task was employed.

There was a curious 35 year gap of a lack of interest in investigating latent inhibition in children until McLaren, Civile & McLaren (2021) conducted a study to try and replicate Kaniel and Lubow's findings. There were three groups of children: 4-5 year olds; 6-9 year olds and 10-11 year olds. In their study phase, participants had to decide whether to respond to the pictures of dinosaurs or not and this depended on whether the patterns that preceded the dinosaurs were followed by a certain tone. In the test stage, they were presented with preexposed and novel patterns and were asked to press the spacebar after each tone. Their results observed that accuracy for the novel stimuli was higher across age groups but only children ages 4-5 showed a latent inhibition effect and no differences between the preexposed and novel patterns were observed in the older children, replicating previous findings.

The aim of this study was to, therefore, replicate previous findings that latent inhibition can only be found in younger children but not older children. It can be suggested that the tasks used by Kaniel and Lubow (1986) and McLaren et al. (2021), were too easy to solve for older children. This is because in the former study, children ages 7 and above in both the pre-exposed and non-preexposed took the same amount of time to reach criterion, demonstrating a floor effect. In the latter study, children ages 6-9 show about 80% accuracy for preexposed and novel patterns while children ages 10-11 shows about 90% accuracy, demonstrating a ceiling effect.

The design by Granger, Moran, Buckley & Haselgrove (2016) is a good alternative to use to further study latent inhibition in children. This is because it has been shown to generate latent inhibition in adults without a masking task, see Chapter 4 and 5 results. This study will replicate

McLaren et al.'s age groups and predicted that latent inhibition can be demonstrated across all ages.

E2: Methods

E2.1: Participants

Participants (n = 83; Males = 31; age range = 4-11 years old) were recruited through Summer Scientist Week, an annual public engagement event held by the University of Nottingham School of Psychology. As in McLaren, Civile & McLaren (2021), the children were separated into 3 groups; 4-5 year olds (n = 10); 6-9 year olds (n = 47); 10-11 year olds (n = 26).

E2.2: Apparatus

An iMac with a 21.5-inch screen (UK campus) with Psychopy (version 1.85.2; Peirce, 2007) installed were used to present stimuli to participants, record responses and control the experimental events. Participant's responses were recorded using a mouse.

E2.3: Materials

The stimuli were white capital letters in Arial font presented for 1000 ms each on a grey background. The stimulus letters were “S” and “H”. One of the letters served as the preexposed cue while the other served as the non-preexposed cue, counterbalanced across participants. The target (outcome) was the letter “X”, with non-target letters D, M, T, V.

E2.4: Procedure

The experiment begins with an information screen containing instructions for the task and they were read to the children.

"*I want you to watch the letters that will appear on the screen. I would like you to say the letters out loud as the appear*.

This will take about 3 minutes to do, then we are going to do something else."

In the pre-exposure stage, the children were presented with a string of letters and were asked to say out loud each of the letters that appeared on the screen. The letters had a 50 ms inter-stimulus interval between each other. The preexposed stimulus, either 'H' or 'S' would be presented along with this string of letters.

Following Stage 1, a second set of instructions was presented to the participants, before the test stage began.

"*Now, for this part of the game, I want you to watch the letters on the screen again. But now, don't say anything. Instead I want you to press the spacebar whenever you think the letter X is going to appear. At first it is OK to just press the spacebar when you see X, but as you keep going, see if you learn when it going to come on so you can press the space bar first!*

If you understand the rules, you can start now."

In the test stage, the preexposed and non-preexposed cues were each presented 20 times followed by the target letter "X". Intermixed with these pairing were also 20 non-cued presentations of X during which the target was preceded by one of the 4 filler letters, each of which preceding the target 5 times. There was a total of 64 presentations of each of the filler letters throughout the test phase. All the letters were presented for 1000 ms with an inter-stimulus interval of 50 ms. Participants were required to press the spacebar when X appeared on the screen or if they could predict when X would appear as the next letter in the sequence, see Figure E.2 for an illustration of the test stage trials and overall design.

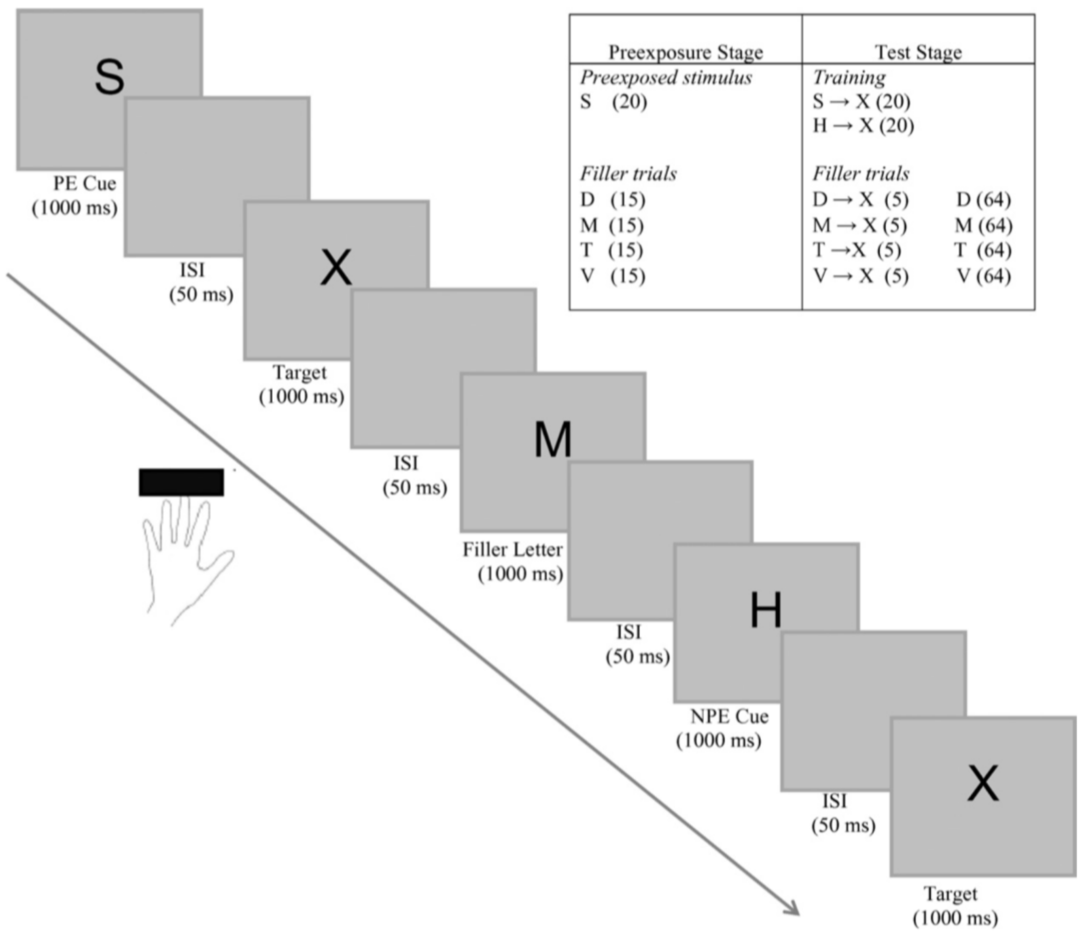


Figure E2: Example of test trials and overall design, taken from Granger et al., (2016).

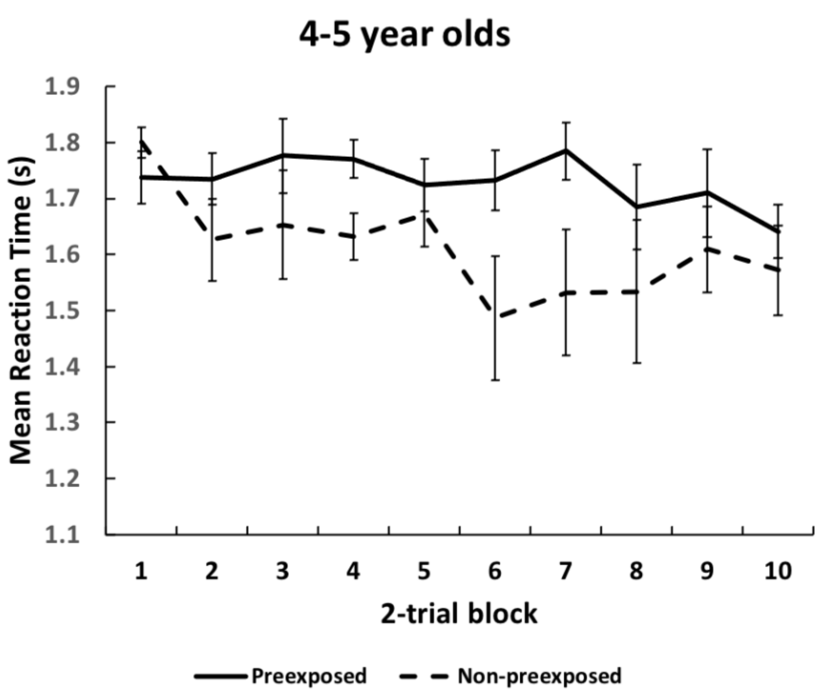
E3: Results

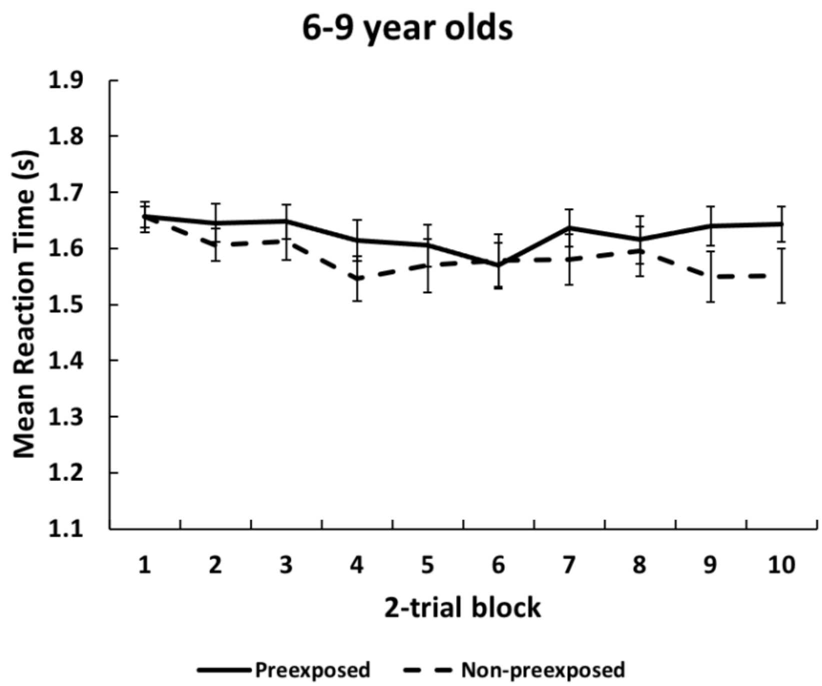
E3.1: Data treatment

As there were a lot of missed trials (4-5 years old, n_{trials} = 159; 6-9 years old, n_{trials} = 217; 10-11 years old, n_{trials} = 62), the data was imputed (provide estimates for the missing values from an existing dataset) using an R package, missForest, for all 20 trials. Two trial blocks were then computed making 10 trial blocks.

A "latent inhibition score" was obtained by subtracting the nonpre-exposed (NPE) cue reaction times from the preexposed (PE) cue reaction times. Thus, this latent inhibition score will serve as a magnitude of how learning about the preexposed stimulus is retarded (greater reaction times) compared to the non-preexposed stimulus (quicker reaction times).

E3.2: Analyses





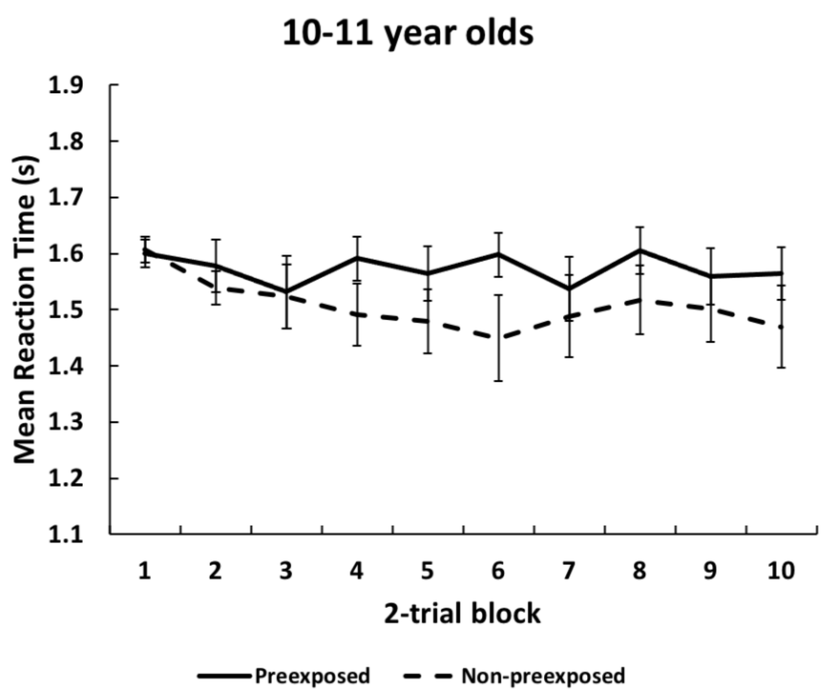


Figure E3: Mean reaction times for PE and NPE cues in groups, a) 4-5, b) 6-9 and c) 10-11 year olds

Mean reaction times can range from 0 to 2050 ms. If the reaction times were less than 1050 ms, X was anticipated. If it is between 1050-2050 ms, the children were responding to X. As seen from Figure D3, the reaction time for PE cues is higher than the NPE cues, suggesting a latent inhibition effect in all age groups. This is not confirmed in the 2 (pre-exposure) x 3 (age) x 10 (trial block) mixed design ANOVA. There was a three-way interaction, $F(9,720) = 2.70$, $p < 0.001$, $\eta^2_p = 0.06$, an interaction effect of trial block and age, $F(9,720) = 3.52$, $p < 0.001$, , $\eta^2_p = 0.08$, an interaction effect of pre-exposure and trial block, $F(9,720) = 4.24$, $p < 0.001$, , $\eta^2_p = 0.05$ and a main effect of trial, $F(9,720) = 4.18$, $p < 0.001$, $\eta^2_p = 0.05$. There were no interaction effect of pre-exposure and age, no main effect of age, and no main effect of pre-exposure, $F(1,80) = 1.37$, $p = 0.25$, $\eta^2_p = 0.02$.

Post-hoc analyses revealed a main effect of trial in 4-5 year olds, $F(9,81) = 2.44$, $p = 0.02$, $\eta^2_p = 0.21$, but not in 6-9 and 10-11 year olds, largest $F(9,414)= 1.01$, $p = 0.41$, $\eta^2_p = 0.02$. A paired samples t-test was conducted between PE (4-5 year olds: M = 1.74 seconds, SEM = 0.52; 6-9 year olds: M = 1.62 seconds, SEM = 0.03; 10-11 year olds: M = 1.57 seconds, SEM = 0.05) and NPE cues (4-5 year olds: M = 1.60 seconds, SEM = 0.07; 6-9 year olds: M = 1.58 seconds, SEM = 0.03; 10-11 year olds: M = 1.51 seconds, SEM = 0.04). There was a significant difference in 4-5 year olds, $t(9) = 2.16$, $p = 0.03$, $d = 0.68$, $BF_{10}= 2.97$, and 10-11 year olds, $t(25) = 2.29$, $p = 0.02$, $d = 0.45$, $BF_{10}= 3.64$, but not in 6-9 year olds, $t(46) = 1.39$, p = 0.09, $d = 0.203$, $BF_{10} = 0.71$.

E3.3: Regression analyses

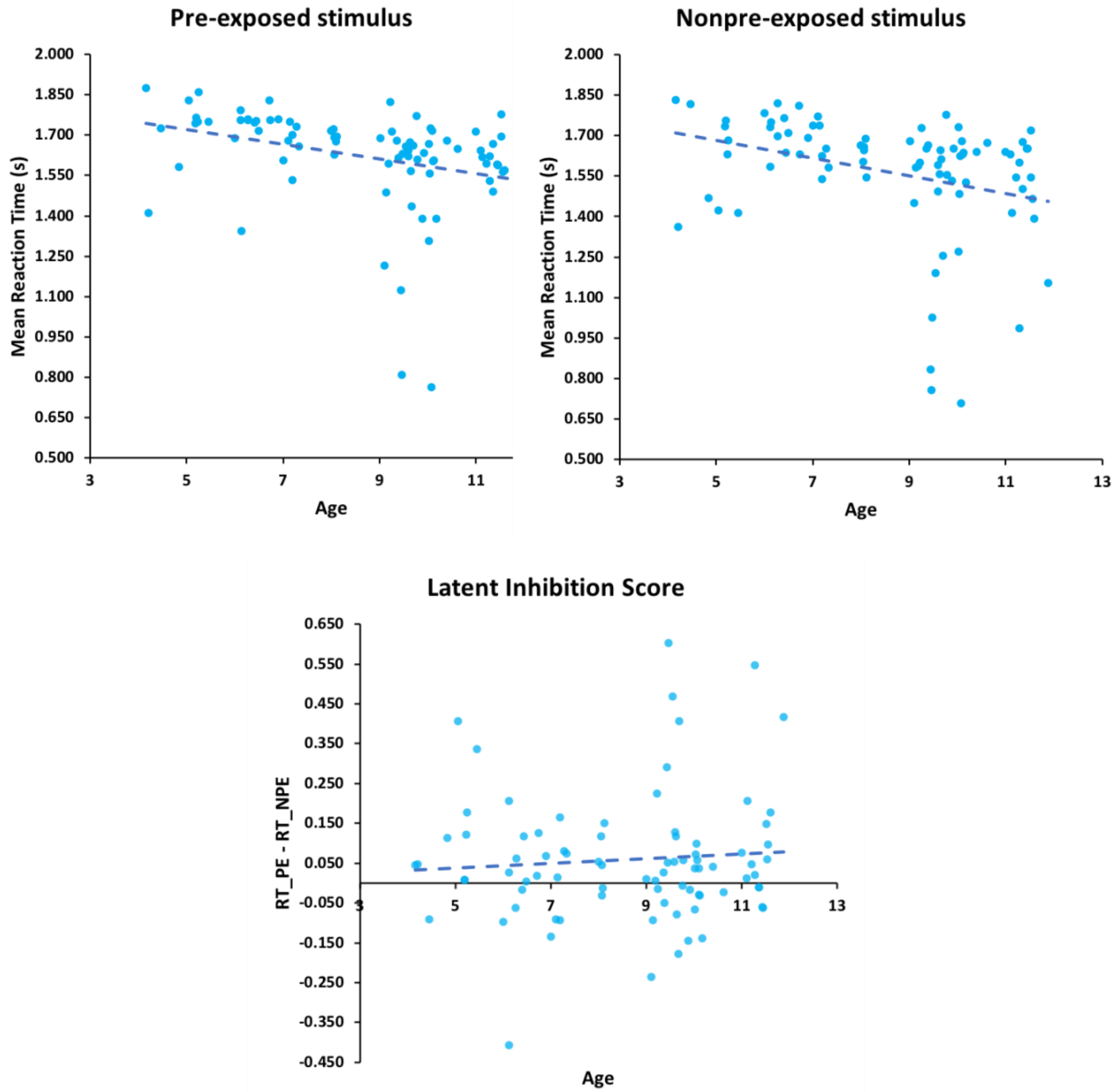


Figure E4: Scatter plots for PE, NPE cues and latent inhibition.

Age as a predictor of pre-exposed and nonpre-exposed cues were significantly greater than the null model (PE = $F(1,81) = 8.59$, $p = 0.004$, R2 = 0.10, R2 adjusted = 0.09, standardized $\beta = -0.31$, $BF_{10} = 8.70$; $F(1,81) = 8.04$, $p = 0.01$, R2 = 0.09, R2 adjusted = 0.08, standardized $\beta = -0.30$, $BF_{10} = 6.94$) but latent inhibition was not significant, $F(1,81) = 0.14$, $p = 0.71$, R2 = 0.002, R2 adjusted = -0.01, standardized $\beta = 0.04$, $BF_{10} = 0.24$.

E4: Discussion

The aim of this thesis was to replicate previous findings where latent inhibition was observed in younger but not older children. A letter prediction task (Granger et al., 2016) was employed as it has been demonstrated to generate latent inhibition in adults. Findings from this study revealed that children ages 4-5 and 10-11 showed a latent inhibition effect, and there was anecdotal evidence of 6-9 year olds showing latent inhibition. It was also revealed that reaction times for both pre-exposed and nonpre-exposed decreased as age increased. Also, age was not a predictor of the magnitude of latent inhibition.

According to Piaget's (1936) developmental stages, children ages 2-7 (pre-operational stage) tend to think in simple concrete ways while children ages 7-11 (concrete operational stage) begin to use logic when thinking about concepts. This is perhaps why Lubow et al. (1982) only found latent inhibition in 10-11 year olds when a masking task was used. Furthermore, Spiker & Cantor (1982) proposes that as age increases chronologically, children are more likely to use previously relevant information to solve tasks and their ability to think abstractly improves with age as well.

Past studies have shown that latent inhibition is really easy to demonstrate in younger children and thus, the use of the letter prediction task may not actually have made an impact.

Instead, its validity to generate latent inhibition without a masking task is clearly observed in the 10-11 year olds. Therefore, an explanation as to why children in the 6-9 age group showed a weak effect of latent inhibition is perhaps it is in the middle of the preoperational stage. Children in this age group are transitioning from a younger developmental stage (4-5 year old) to an older developmental stage (10-11 year old), and hence, the reduced latent inhibition effect could be due to the on-going and incomplete process of switching from a basic form of thinking to a more logic-based thinking.

In conclusion, this study used an alternate latent inhibition task that did not require a masking task to successfully demonstrate latent inhibition in 4-5 and 10-11 year olds. A potential reason why latent inhibition in 6-9 year olds are reduced was discussed. Further research should involve recruiting more participants especially in the younger children age groups.

Appendix F: Path analysis – Big 5 and OLIFE

F1: Aims

To the best of knowledge, only Asai et al. (2015) have conducted a systematic study on the relationship between the Big 5 personality traits (Costa & McCrae, 1992) and the OLIFE (Mason & Claridge, 2006) dimensions. The path analysis was conducted to replicate Asai et al.'s findings because the findings in their study is heavily used throughout this thesis. Also, this analysis aims to determine if there are cultural differences in the relationship between the Big 5 and OLIFE traits.

F2: Methods

F2.1: Participants

The psychometric data from participants in Chapter 4, 5 and 6 were combined, making the total number of participants, n = 641. When separated by culture using the method in Chapter 4, the sample size for the individualistic group is, n = 315, and the sample size for the collectivistic group is, n = 326.

F2.2: Data treatment

A reliability analysis was conducted for the OLIFE, STICSA and Big 5 questionnaires using Jamovi. The values are as follows: 1) OLIFE ([unusual experiences, introvertive anhedonia, cognitive disorganization, impulsive nonconformity], McDonald's omega = 0.86, 0.82, 0.87, 0.72 respectively); 2) Big 5 ([openness, conscientiousness, extraversion, agreeableness and emotional stability], McDonald's omega = 0.73, 0.78, 0.84, 0.79, 0.77 respectively). According to Feiβt et al. (2019), a score of more than 0.8 is considered to have good internal reliability.

A path analysis using the lavaan package on RStudio was conducted to determine the relationship between the Big 5 and OLIFE and the cut-off points for the model fit are: CFI > 0.90, RMSEA <

0.05, SRMR < 0.05, EVCI > 0.05. Although the $x2$ will be reported, the value would only be sensitive to a sample of less than 200. It is thought of that a model has good fit if more than 2 of the cut-off point values are met.

F3: Results

F3.1: Comparison of lab-based and online data

Table F1: Summary of between subjects t-test, n = 641, df = 639.

	Experiment	Mean	SE	t	p	BF_{10}	d
Big 5							
Openness	lab	45.92	0.42	-1.79	0.07	0.43	-0.14
	online	46.94	0.37				
Conscientiousness	lab	43.13	0.51	-1.08	0.28	0.16	-0.09
	online	43.86	0.45				
Extraversion	lab	40.94	0.60	3.12	0.002	10.00	0.25
	online	38.46	0.52				
Agreeableness	lab	46.37	0.50	0.77	0.44	0.12	0.06
	online	45.87	0.42				
Emotional Stability	lab	36.72	0.56	-0.46	0.64	0.10	-0.04
	online	37.06	0.46				
OLIFE							
Unusual Experiences	lab	10.71	0.37	0.34	0.74	0.09	0.03
	online	10.55	0.32				
Introvertive Anhedonia	lab	7.46	0.30	-0.13	0.19	0.21	-0.11
	online	8.00	0.27				
Cognitive Disorganization	lab	14.73	0.34	0.82	0.42	0.12	0.07
	online	14.36	0.30				
Impulsive Nonconformity	lab	7.63	0.24	-0.48	0.63	0.10	-0.04
	online	7.78	0.19				

F.3.2.i: All

Table F2 shows the mean and standard error of mean of the Big 5 and OLIFE personality scores for all participants. Table F3 shows the correlation matrix of the Big 5 personality traits and OLIFE subscales for all participants. The Big 5 subscales as a predictor of the OLIFE subscales were all significantly greater than the null model, (unusual experiences = $F(5, 635) = 11.19$, $p < 0.001$, $R^2 = 0.08$, adjusted $R^2 = 0.07$; introvertive anhedonia = $F(5, 635) = 75.78$, $p < 0.001$, $R^2 = 0.37$, adjusted $R^2 = 0.37$; cognitive disorganization, $F(5, 635) = 78.98$, $p < 0.001$, $R^2 = 0.38$, adjusted $R^2 = 0.38$; impulsive nonconformity = $F(5, 635) = 49.57$, $p < 0.001$, $R^2 = 0.28$, adjusted $R^2 = 0.28$), see Table F4 for summary of coefficients. A path analysis was conducted to determine the relationship between the Big 5 and schizotypy at each factor level, see Figure F1. The model was fitted using the maximum likelihood robust and the p-values were bootstrapped. The model achieved good fit, $x^2 = 18.09$, $p = 0.02$, CFI = 0.99, RMSEA = 0.06, SRMR 0.03, ECVI = 0.28.

Table F2: Means and standard error of mean, n = 641.

	Mean	**SE**
Big 5		
Openness	46.52	0.28
Conscientiousness	43.56	0.34
Extraversion	39.48	0.4
Agreeableness	46.08	0.32
Emotional Stability	36.92	0.36
OLIFE		
Unusual Experiences	10.62	0.24
Introvertive Anhedonia	7.78	0.20
Cognitive Disorganization	14.51	0.22
Impulsive Nonconformity	7.71	0.15

Table F3: Correlation matrix of the Big 5 personality traits and the OLIFE subscales for all participants. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

	Openness (r)	Conscientiousness (r)	Extraversion (r)	Agreeableness (r)	Emotional Stability (r)
Unusual Experiences	0.07	-0.16***	0.04	-0.10*	-0.18***
Introvertive Anhedonia	-0.21***	-0.13***	-0.58***	-0.41***	-0.22***
Cognitive Disorganization	-0.21***	-0.3***	-0.39***	-0.24***	-0.57***
Impulsive Nonconformity	-0.04	-0.37***	0.11*	-0.26***	-0.31***

Table F4: Summary of Big 5 subscales as predictors and the subscales of the OLIFE as dependent variables. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	Unusual Experiences		Introvertive Anhedonia		Cognitive Disorganization		Impulsive Nonconformity	
	Standardized β	$BF_{inclusion}$	Standardized β	$BF_{inclusion}$	Standardized β	$BF_{inclusion}$	Standardized β	$BF_{inclusion}$
Openness	0.15***	138.30	0.02	0.27	0.002	0.48	0.09*	8.85
Conscientiousness	-0.17***	496.50	0.09*	5.31	-0.12**	29.92	-0.32***	2.65E+11
Extraversion	0.12**	9.40	-0.52***	6.03E+25	-0.24***	2.48E+07	0.34***	8.09E+13
Agreeableness	-0.05	1.43	-0.23***	51766.02	0.14***	52.45	-0.19***	5214.39
Emotional Stability	-0.18***	1368.26	0.04	0.36	-0.5***	5.03E+34	-0.27***	2.51E+09

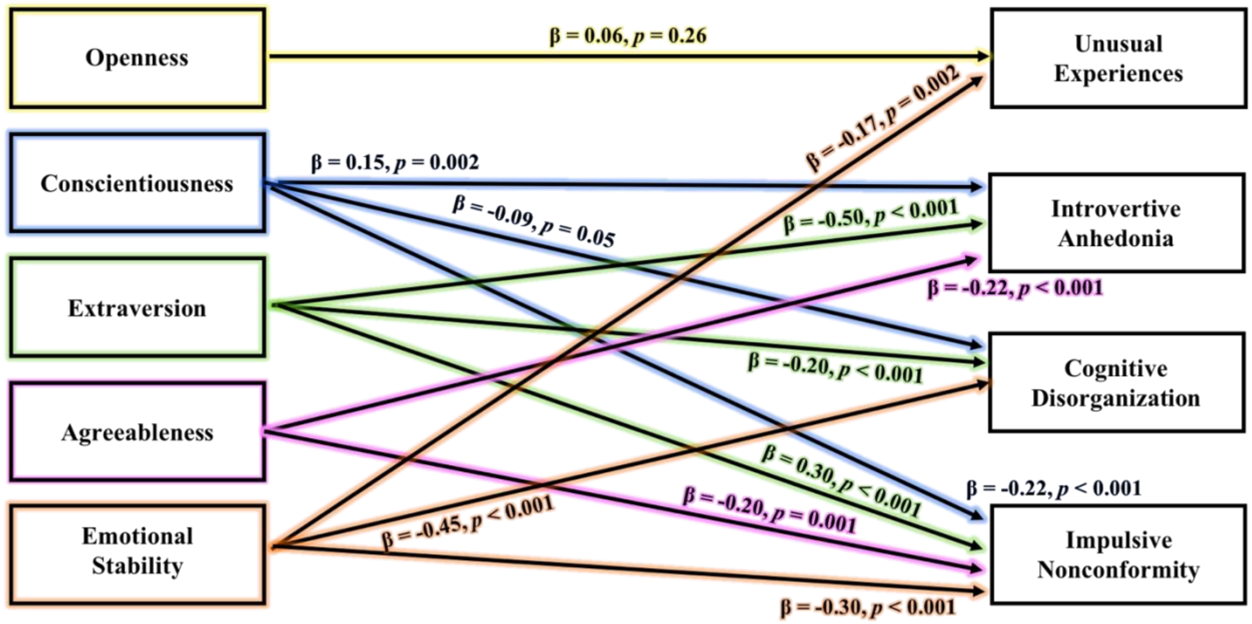


Figure F1: Path model of the Big 5 subscales to the OLIFE subscales for all participants, n = 641.

F.3.2.ii: Individualistic

Table F5 shows the mean and standard error of mean of the Big 5 and OLIFE personality scores for all participants. Table F6 shows the correlation matrix of the Big 5 personality traits and OLIFE subscales for all participants. The Big 5 subscales as a predictor of the OLIFE subscales were all significantly greater than the null model, (unusual experiences = $F(5, 309)$ =7.69, $p < 0.001$, $R^2 = 0.11$, adjusted $R^2 = 0.10$; introvertive anhedonia = $F(5, 309) = 41.35$, $p < 0.001$, $R^2 = 0.40$, adjusted $R^2 = 0.40$; cognitive disorganization, $F(5, 309) = 41.02$, $p < 0.001$, $R^2 = 0.40$, adjusted $R^2 = 0.39$; impulsive nonconformity = $F(5, 309)$ =25.69, $p < 0.001$, $R^2 = 0.98$, adjusted $R^2 = 0.28$), see Table 7 for summary of coefficients. A path analysis was conducted to determine the relationship between the Big 5 and schizotypy at each factor level, see Figure F2. The model was fitted using the maximum likelihood robust and the p-values were bootstrapped.

The model achieved good fit, x^2 = 15.33, p = 0.03, CFI = 0.99, RMSEA = 0.06, SRMR 0.03, ECVI = 0.29.

Table F5: Means and standard error of mean, n = 315.

	Mean	SE
Big 5		
Openness	47.20	0.38
Conscientiousness	45.07	0.47
Extraversion	40.47	0.56
Agreeableness	46.64	0.47
Emotional Stability	37.28	0.52
OLIFE		
Unusual Experiences	9.30	0.34
Introvertive Anhedonia	6.91	0.29
Cognitive Disorganization	14.12	0.32
Impulsive Nonconformity	7.93	0.22

Table F6: Correlation matrix of the Big 5 personality traits and the OLIFE subscales for individualistic group. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

	Openness (r)	Conscientiousness (r)	Extraversion (r)	Agreeableness (r)	Emotional Stability (r)
Unusual Experiences	0.13*	-0.13*	0.08	-0.11	-0.22***
Introvertive Anhedonia	-0.22***	-0.1	-0.6***	-0.41***	-0.22***
Cognitive Disorganization	-0.17***	-0.21***	-0.4***	-0.21***	-0.58***
Impulsive Nonconformity	-0.02	-0.38***	0.16**	-0.26***	-0.28***

Table F7: Summary of Big 5 subscales as predictors and the subscales of the OLIFE as dependent variables. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**Unusual Experiences**		**Introvertive Anhedonia**		**Cognitive Disorganization**		**Impulsive Nonconformity**	
	Standardized β	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
Openness	0.20**	38.32	0.03	0.32	-0.03	0.51	0.08	2.32
Conscientiousness	-0.14*	10.22	0.10	1.78	-0.06	0.74	-0.34***	6.82E+06
Extraversion	0.14*	4.93	-0.53***	1.92E+19	-0.27***	2.94E+04	0.34***	2.17E+07
Agreeableness	-0.08	1.73	-0.27***	647.59	0.17**	6.69	-0.18**	30.92
Emotional Stability	-0.21***	193.28	0.04	0.33	-0.54***	3.61E+19	-0.23***	3920.57

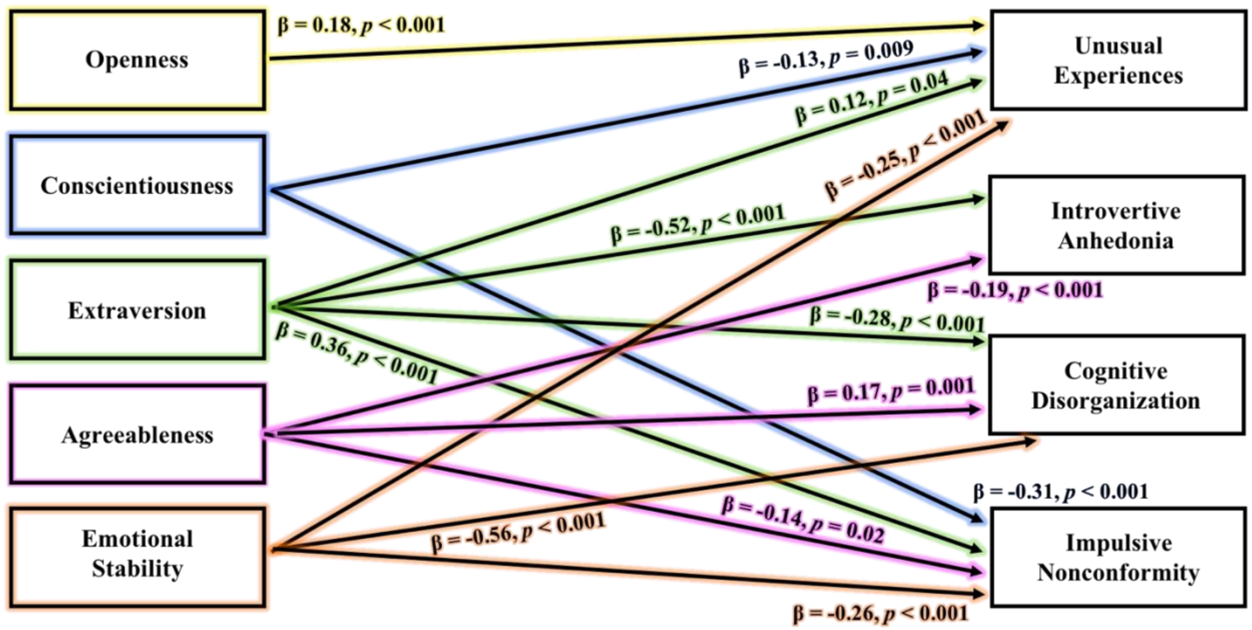


Figure F2: Path model of the Big 5 subscales to the OLIFE subscales for the individualistic group, n = 315.

F.3.2.iii: Collectivistic

Table F8 shows the mean and standard error of mean of the Big 5 and OLIFE personality scores for all participants. Table F9 shows the correlation matrix of the Big 5 personality traits and OLIFE subscales for all participants. The Big 5 subscales as a predictor of the OLIFE subscales were all significantly greater than the null model, (unusual experiences = $F(5, 320) = 3.66$, $p = 0.003$, $R^2 = 0.05$, adjusted $R^2 = 0.04$; introvertive anhedonia = $F(5, 320) = 33.30$, $p < 0.001$, $R^2 = 0.34$, adjusted $R^2 = 0.33$; cognitive disorganization, $F(5, 320) = 37.83$, $p < 0.001$, $R^2 = 0.37$, adjusted $R^2 = 0.36$; impulsive nonconformity = $F(5, 320) = 25.52$, $p < 0.001$, $R^2 = 0.29$, adjusted $R^2 = 0.27$), see Figure F10 for summary of coefficients. A path analysis was conducted to determine the relationship between the Big 5 and schizotypy at each factor level, see Figure F3. The model was fitted using the maximum likelihood robust and the p-values were bootstrapped.

The model achieved good fit, x^2 = 19.58, p = 0.02, CFI = 0.99, RMSEA = 0.06, SRMR 0.04, ECVI = 0.28.

Table E8: Means and standard error of mean, n = 326.

	Mean	SE
Big 5		
Openness	45.87	0.41
Conscientiousness	42.11	0.47
Extraversion	38.52	0.55
Agreeableness	45.53	0.43
Emotional Stability	36.57	0.48
OLIFE		
Unusual Experiences	11.89	0.33
Introvertive Anhedonia	8.61	0.27
Cognitive Disorganization	14.88	0.31
Impulsive Nonconformity	7.51	0.21

Table F9: Correlation matrix of the Big 5 personality traits and the OLIFE subscales for collectivistic group. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

	Openness (r)	Conscientiousness (r)	Extraversion (r)	Agreeableness (r)	Emotional Stability (r)
Unusual Experiences	**0.05**	-0.13*	**0.05**	**-0.07**	-0.14*
Introvertive Anhedonia	-0.19***	**-0.1**	-0.56***	-0.39***	-0.22***
Cognitive Disorganization	-0.23***	-0.37***	-0.38***	-0.27***	-0.57***
Impulsive Nonconformity	**-0.07**	-0.39***	**0.05**	-0.26***	-0.35***

Table F10: Summary of Big 5 subscales as predictors and the subscales of the OLIFE as dependent variables. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**Unusual Experiences**		**Introvertive Anhedonia**		**Cognitive Disorganization**		**Impulsive Nonconformity**	
	Standardized β	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
Openness	0.12	1.08	0.01	0.33	0.03	0.54	0.10	4.26
Conscientiousness	-0.12	1.36	0.12*	2.61	-0.18*	9.5	-0.31***	84036.64
Extraversion	0.13	1.34	-0.5***	8.43E+14	-0.2***	26.17	0.32***	323889.36
Agreeableness	-0.05	0.53	-0.21***	11.51	0.10	1.5	-0.19**	63.66
Emotional Stability	-0.16*	2.85	0.03	0.35	-0.47***	4.35E+13	-0.31***	349581.75

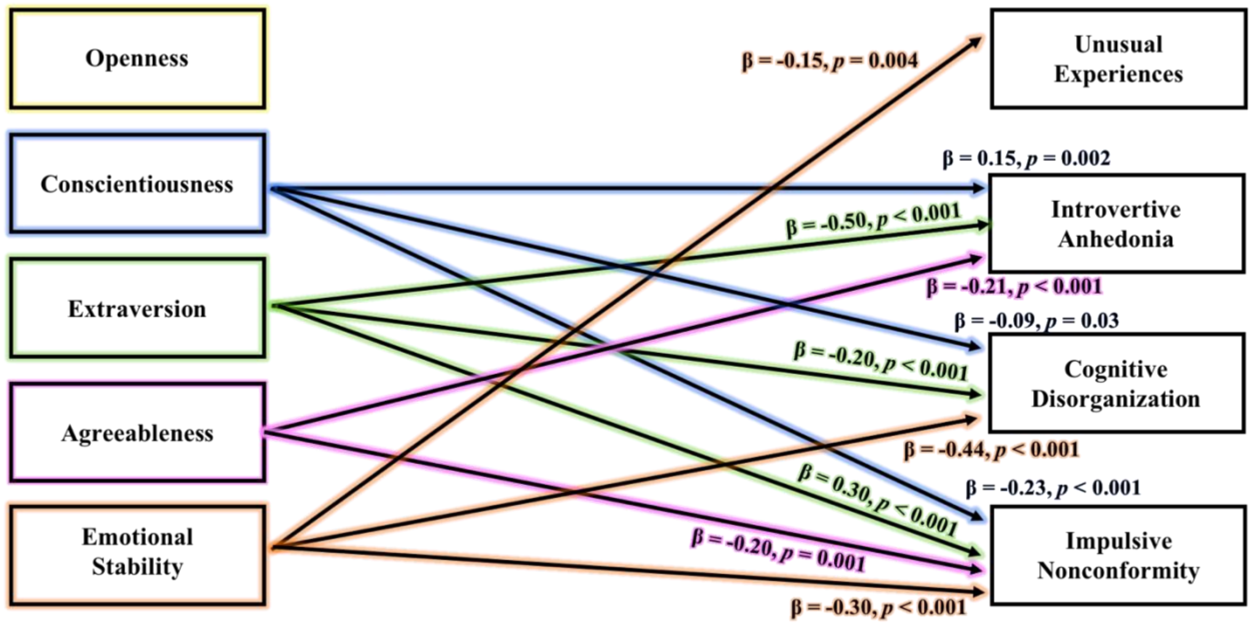


Figure F3: Path model of the Big 5 subscales to the OLIFE subscales for collectivistic group, n = 326.

Appendix G

Chapter 4: Study 5

Table G1: Summary of anxiety as predictor and response times to the pre-exposed cues, nonpre-exposed cues and latent inhibition score as dependent variables. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	PE		NPE		LIScore	
Anxiety	Standardized β	$BF_{inclusion}$	Standardized β	$BF_{inclusion}$	Standardized β	$BF_{inclusion}$
All participants (n = 263)	0.07	0.15	-0.03	0.15	0.07	0.24
Individualistic (n = 102)	0.002	0.21	-0.02	0.21	0.03	2.20E-01
Collectivistic (n = 161)	0.03	0.18	-0.06	0.21	0.10	0.37

Table G2: Summary of anxiety as predictor and response times to the difference score to the relevant and irrelevant stimuli and learned predictiveness score as dependent variables. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	Relevant		Irrelevant		LPScore	
Anxiety	Standardized β	$BF_{inclusion}$	Standardized β	$BF_{inclusion}$	Standardized β	$BF_{inclusion}$
All participants (n = 263)	0.03	0.15	< 0.001	0.14	0.03	0.15
Individualistic (n = 102)	-0.002	0.21	0.04	0.23	-0.03	0.22
Collectivistic (n = 161)	0.05	0.21	-0.03	0.18	0.09	0.30

Table G3: Summary of the Big 5 personality traits as predictor and response times to the pre-exposed cues, nonpre-exposed cues and latent inhibition score as dependent variables. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**PE**		**NPE**		**LIScore**	
Big 5	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All participants (n = 263)						
Openness	-0.09	0.17	-0.14	0.28	0.07	0.06
Conscientiousness	-0.04	0.09	0.03	0.13	-0.08	0.10
Extraversion	-0.11	0.15	-0.06	0.12	-0.06	0.08
Agreeableness	0.05	0.09	0.08	0.17	-0.04	0.09
Emotional Stability	0.15*	0.21	0.13	0.32	0.01	0.06
Individualistic (n = 102)						
Openness	-0.08	0.21	-0.19	0.39	0.13	0.166
Conscientiousness	-0.02	0.13	0.11	0.26	-0.15	0.28
Extraversion	-0.17	0.24	-0.12	0.25	-0.06	< 0.001
Agreeableness	-0.01	0.13	0.10	0.24	-0.13	0.25
Emotional Stability	0.13	0.15	0.13	0.26	-0.002	0.15
Collectivistic (n = 161)						
Openness	-0.09	0.13	-0.13	0.16	0.05	0.07
Conscientiousness	-0.01	0.11	0.05	0.14	-0.07	0.07
Extraversion	-0.04	0.11	0.07	0.17	-0.13	0.11
Agreeableness	0.10	0.18	0.06	0.2	0.05	0.07
Emotional Stability	0.14	0.28	0.09	0.22	0.04	0.07

Table G4: Summary of anxiety as predictor and response times to the pre-exposed cues, nonpre-exposed cues and latent inhibition score as dependent variables. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**PE**		**NPE**		**LIScore**	
Anxiety	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All participants (n = 131)	0.03	0.20	0.05	0.22	-0.04	0.20
Individualistic (n = 80)	0.08	0.29	0.90	0.30	-0.02	0.24
Collectivistic (n = 51)	-0.03	0.29	0.01	0.28	-0.04	0.29

Table G5: Summary of the OLIFE subscales as predictor and response times to the pre-exposed cues, nonpre-exposed cues and latent inhibition score as dependent variables. *Note*: $p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Coefficients	**PE**		**NPE**		**LIScore**	
OLIFE	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**	**Standardized β**	**$BF_{inclusion}$**
All participants (n = 131)						
Unusual Experiences	0.13	0.16	0.18	0.2	-0.09	0.12
Introvertive Anhedonia	-0.17	0.23	-0.09	0.13	-0.07	0.12
Cognitive Disorganization	0.09	0.15	0.07	0.14	0.01	0.10
Impulsive Nonconformity	-0.10	0.13	-0.11	0.13	0.03	0.10
Individualistic (n = 80)						
Unusual Experiences	0.16	0.20	0.22	0.26	-0.11	0.16
Introvertive Anhedonia	-0.19	0.25	-0.12	0.19	-0.07	0.16
Cognitive Disorganization	0.15	0.24	0.14	0.26	-0.01	0.14
Impulsive Nonconformity	-0.13	0.19	-0.19	0.22	0.10	0.14
Collectivistic (n = 51)						
Unusual Experiences	0.07	0.19	0.08	0.19	-0.02	0.17
Introvertive Anhedonia	-0.16	0.24	-0.07	0.18	-0.09	0.17
Cognitive Disorganization	0.03	0.18	-0.02	0.17	0.06	0.17
Impulsive Nonconformity	-0.01	0.18	0.05	0.19	-0.07	0.18