

Examining Individual Differences in Imagery- and Simulation-Based Processes
and Their Links to Mental Health

by

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Abstract

This dissertation explored how individual differences in the personality variables alexithymia and sensory processing sensitivity (SPS) relate to three specific cognitive-affective mechanisms that involve imagery- and simulation-based processes: motor simulation, mentalizing, and future thinking. It also addressed the question of whether accounting for these personality variables might help to explain previously reported links between these three mechanisms and symptoms of anxiety and depression. In Study 1, I assessed individuals' use of spatial embodiment vs. motoric simulation when completing a hand laterality judgment task and whether this differed depending on endorsement of personality variables. Results of Study 1 ($N = 134$) supported the conclusion that people generally use spatial embodiment when processing back views of hands and motoric simulation when processing palm views; however, SPS was related to the tendency to apply motoric simulation more broadly. Alexithymia and SPS accounted for unique variance in depression and anxiety when controlling for performance variables and participant sex. In Study 2, I assessed bias in how information about another's changing emotion is represented in working memory. Results of Study 2 ($N = 145$) offered preliminary support for the idea that individuals who score high (vs. low) on orienting sensitivity (a feature of SPS) display a stronger tendency to anticipate a negative shift in another's affective state when viewing a fading expression of joy. As in Study 1, alexithymia and SPS were stronger predictors of the severity of anxiety and depression symptoms than task performance. In Study 3, I assessed how personality and mental health variables related to variables such as the vividness of cued imagery regarding future events and the tendency to experience intrusive thoughts and images and to view negative events as being likely to occur. Results of Study 3 ($N = 167$) suggested that facets of alexithymia and/or SPS accounted for unique variance in future thinking which, in turn, predicted the severity

of symptoms of anxiety and depression. Implications for clinical practice and future directions were discussed.

Keywords: mental imagery, mental rotation, emotion anticipation, future thinking, alexithymia, sensory processing sensitivity, anxiety, depression

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Table of Contents

Abstract	ii
Acknowledgements	iv
List of Tables	viii
List of Figures	ix
List of Abbreviations	x
CHAPTER 1: GENERAL INTRODUCTION	1
Kosslyn’s Theory of Visual Imagery and its Relationship to Mental Rotation, Embodiment, and Motor Imagery	2
Links Between Imagery and Working Memory, Long Term Memory, and Future Thinking	3
Individual Differences in Imagery and Simulation	7
Links Between Individual Differences in Mental Imagery/Simulation and Mental Health	10
Overview of the Research	11
CHAPTER 2: EXPLORING INDIVIDUAL DIFFERENCES IN MOTOR IMAGERY AND THEIR LINKS TO MENTAL HEALTH	14
Studying Motor Imagery Using the Hand Laterality Task (HLT)	15
Individual Differences in HLT Performance	16
Links to Mental Health	18
The Current Study	19
Method	21
Participants	21
General Procedure	21
Questionnaire Measures	22
<i>Toronto Alexithymia Scale</i>	22
<i>Highly Sensitive Person Scale</i>	22
<i>Patient Health Questionnaire-9</i>	22
<i>General Anxiety Disorder-7</i>	23
Experimental Task	23
Results	24
Data Cleaning and Statistical Analysis	24
Objective 1: To Determine if Performance on the HLT Varies Depending on the View of the Hand Shown or Participant Sex	24
Objective 2: Exploring the Relationships Between Performance on the HLT and Personality Variables	27

Objective 3: Testing the Relationships Between Performance on the HLT and Mental Health ...	29
Discussion	29
Strengths, Limitations, and Future Directions.....	34
Conclusions.....	35
CHAPTER 3: EMOTION ANTICIPATION EFFECTS	36
Method	43
Participants.....	43
Methods and Procedure	43
<i>General Procedure</i>	<i>43</i>
<i>Experimental Task</i>	<i>44</i>
<i>Self-Report Measures Unique to the Study</i>	<i>46</i>
Results	47
Data Cleaning and Statistical Analysis	47
Correction for Perceptual Bias	48
Objective 1: Testing for EA Effects.....	49
Descriptive Statistics and Zero-order Correlations	51
Objective 2: To Determine if SPS and/or Alexithymia are Directly or Indirectly Related to the Size of OBs Seen in the Identity-maintained Condition	51
Objective 3: Determining if Those Reporting Significant Anxiety or Depression Exhibit a “Negativity Bias” in Task Performance.....	54
Objective 4: Determining if Personality Captures Unique Variance in Anxiety and Depression Beyond That Accounted for by Emotion Anticipation	56
Discussion	57
Strengths and Limitations.....	62
Conclusions.....	63
CHAPTER 4: FUTURE THINKING	65
Individual Differences in FT: Links to Alexithymia and SPS.....	67
Links Between FT and Mental Health	69
The Present Study	73
Method	77
Participants.....	77
General Procedure	77
Measures Unique to the Current Study	78
<i>The Impact of Future Events Scale.....</i>	<i>78</i>

<i>Intrusive Visual Imagery and Verbal Thought Questionnaires</i>	78
<i>Prospective Imagery Test</i>	79
Results	79
Data Cleaning and Statistical Analysis	79
Objective 1: Examining Relationships Between Aspects of FT	80
Objective 2: Do Facets of Alexithymia and/or SPS Account for Unique Variance in FT?	84
Discussion	89
Examining Relationships Between Aspects of Future Thinking	89
Do Facets of Alexithymia and/or SPS Account for Unique Variance in FT?	92
How Do Aspects of FT Relate to Depression and Anxiety in University Students?	95
Strengths and Limitations	97
Conclusions	98
CHAPTER 5: KEY FINDINGS AND CLINICAL IMPLICATIONS	99
Summary of Key Findings from Each Study	99
Clinical Implications	101
<i>Therapeutic Approaches Involving the Use of Motor Imagery</i>	101
<i>Therapeutic Approaches to Address Biases Related to Emotion Anticipation</i>	104
<i>Therapeutic Approaches to Address Biases in Future Thinking</i>	108
<i>Directions for Future Research</i>	113
References	116
Appendix	156

List of Tables

Table 2.1. <i>Correlations Between Task Performance at 120° Rotation and Scores on Questionnaire Measures</i>	27
Table 2.2. <i>Relationships Between Personality Variables and Task Performance in the HLT at 120° Rotation</i>	28
Table 2.3. <i>Relationships Between Overall Task Performance at 120° Rotation in the HLT and Mental Health Outcomes</i>	30
Table 3.1. <i>Descriptive Statistics and Zero-order Correlations</i>	52
Table 3.2. <i>Mediation of the Link Between Severity of Anxiety/Depression and Overshoots Associated with Processing of Joy-to-neutral Sequences</i>	56
Table 3.3. <i>Relationships Between Task Performance in the Identity-maintained Condition, Personality, and Mental Health</i>	57
Table 4.1. <i>Descriptive Statistics for and Correlations Between Self-Report Measures</i>	81
Table 4.2. <i>Relationships Future Thinking Variables</i>	83
Table 4.3. <i>Relationships Between Personality Variables and Future Thinking</i>	85
Table 4.4. <i>Relationships Between Future Thinking Variables and Depression</i>	88
Table 4.5. <i>Relationships Between Future Thinking Variables and Anxiety</i>	90

List of Figures

Figure 2.1. <i>Response Times as a Function of Angle of Rotation and View of the Hand</i>	26
Figure 2.2. <i>Response Time as a Function of Direction of Rotation, View, and Sex</i>	26
Figure 3.1. <i>Mean Ratings of Neutral Faces Under Different Testing Conditions</i>	50
Figure 3.2. <i>Mean Ratings of Neutral Faces as a Function of Severity of Self-Reported Anxiety or Depression</i>	55

List of Abbreviations

ANOVA – Analysis of Variance

AOR – Angle of Rotation

DSM – Diagnostic and Statistical Manual of Mental Disorders

DDF – Difficulty Describing Feelings

DIF – Difficulty Identifying Feelings

DOR – Direction of Rotation

EA – Emotion Anticipation

EOT – Externally Oriented Thinking

fMRI – Functional Magnetic Resonance Imaging

FT – Future Thinking

GAD-7 – Generalized Anxiety Disorder 7

HFA – High Functioning Autism

HLT – Hand Laterality Task

HSPS – Highly Sensitive Person Scale

IFES – The Impact of Future Events Scale

IVI and IVT – Intrusive Visual Imagery and Verbal Thought Questionnaires

MOLA – Medial-Over-Lateral-Advantage

OB – Overshoot Bias

OS – Orienting Sensitivity

PHQ-9 – Patient Health Questionnaire 9

PTSD – Posttraumatic Stress Disorder

RT – Response Time

SPS – Sensory Processing Sensitivity

TAS-20 – Toronto Alexithymia Scale 20

VVIQ – Vividness of Visual Imagery Questionnaire

CHAPTER 1: GENERAL INTRODUCTION

What happens when you read these words? Do you hear them spoken to you with your own voice? Do you begin seeing them fly by like words on a teleprompter? Or do you start to form images and scenes within your *mind's eye*? Research on imagery has made significant impacts in the literature over the past century-and-a-half, dating back to work done by Galton (1880) which is still cited to this day. When thinking about how someone might recall their favourite meal, their loved one, or a favourite memory, one might conclude that the individual can re-experience each of these moments through the process of utilizing mental imagery. Kosslyn et al. (2001) describe mental imagery as a complex process of either forming mental pictures from memories of seeing such objects or events, registering information through the senses, or shaping previously stored information in new ways. As a result of this robust definition, it is no surprise that researchers debate whether imagery can be conceptualized as a distinct construct, or as part of a sophisticated mechanism (Burton & Fogarty, 2003).

Mental images can arise in any modality (i.e., vision, audition, olfactory, gustatory, tactile). As a result of this phenomenon, researchers have begun to explore how sensory systems are activated during mental imagery. For example, Belardinelli et al. (2009) conducted a functional magnetic resonance imaging (fMRI) study that had participants listen to a verbal cue, form a corresponding mental image, and keep the image in memory until the next trial. The researchers found activation in specific brain regions for multiple sensory modalities, suggesting that mental imagery is not a unimodal process, but rather includes the combined activation of several interconnected areas.

Research over the past several decades has reinforced the idea that mental imagery has strong links with perception. Indeed, Pearson et al. (2015) conducted a review from which they

concluded that simply imagining an object (e.g., an apple) can be considered a weak form of actually viewing that same object. Pearson et al. (2015) go on to explain that we can also recreate our memories and experiences with objects using mental imagery. Interestingly, they argue that an individual does not need to imagine every minute detail of a stimulus they call to mind. For example, they suggest that an individual can mentally imagine a zebra without “seeing” each individual stripe and still be able to distinguish it from a horse.

Kosslyn’s Theory of Visual Imagery and its Relationship to Mental Rotation, Embodiment, and Motor Imagery

According to Stephen Kosslyn, the visual imagery of objects involves a four-step cognitive process (Kosslyn 1996; Kosslyn et al, 2006). This process consists of *generating*, *inspecting*, *maintaining*, and *transforming* an image. When an individual is asked to generate a visual image of an object, they must first retrieve that image from long-term memory. Kosslyn (2005) suggests that the retrieval process is not restricted to visual features; indeed, he notes that many objects are encoded with additional sensory information, such as the sounds they make, what they feel like, and where they are located. Once the image is retrieved, the individual can inspect intricate details of the object and their relations to one another. In order to fully perceive the image, it must be maintained (i.e., kept active) in working memory, where an individual is also able to transform the image by moving and rotating it in their mind’s eye.

One experimental paradigm used to examine these processes is described in the literature as mental rotation. Research on mental rotation dates back to Shepard and Metzler (1971) who had participants judge whether line drawings of two 3-dimensional objects presented from different viewpoints were the same or different. Accurate performance on this task appears to depend, in part, on one’s ability to successfully mentally rotate the objects to bring them into

alignment, as evidenced by the fact that response times (RTs) increase as the discrepancy between the orientations of the figures becomes larger.

In a review paper by Kosslyn et al. (1995), it was suggested that through manipulation of images one can begin imagining full scenes that include movement. Amorim (2003) suggested that *embodiment*, the process of either adopting another's perspective or mapping a stimulus onto one's own body, is key here. This was supported by the fact that, if viewers got advance information about the position of an avatar in an unfamiliar virtual scene, they made faster and more accurate judgments about changes in the positions of objects in that scene when it was subsequently viewed from the avatar's perspective. Thus, seeing the avatar primed a switch that allowed viewers to "see" the world from the avatar's perspective.

Jeannerod (1994) suggested that viewers can also employ motor imagery (motoric simulation/embodiment) to imagine themselves performing an action, either from a first person or third person perspective. The individual typically defaults to the use of visual imagery to set the scene but then applies motor imagery to imagine themselves moving through space or interacting with objects/people in the imagined situation.

Links Between Imagery and Working Memory, Long Term Memory, and Future Thinking

Baddeley and Hitch (1974) explicitly linked mental imagery with working memory. Their original model of working memory included three components: an attentional control system (the central executive) and two short-term storage systems or buffers—the visuospatial sketchpad and the phonological loop. They described these buffers as supporting an individual's ability to maintain and transform visual and verbal/auditory images, respectively. Subsequently, a fourth component was added: the episodic buffer (Baddeley, 2000). This buffer was said to integrate

multimodal information with information stored in long-term memory to create a multidimensional representation of a specific episode that is accessible to conscious awareness.

Baddeley and Andrade (2000) set out to explore how concurrent tasks and long-term memory influenced the vividness of information stored in the visuospatial sketchpad and phonological loop systems. If these are indeed similar yet separate systems, and temporary storage in each depends on active rehearsal, then performing a concurrent task that disrupts one system should only impact vividness ratings for information stored in that system. In a series of experiments, participants were instructed to hold either an auditory or visual stimulus in their mind while performing a concurrent task and then rate how vivid the stimulus was on a scale from 0 (“no image at all”) to 10 (“image as clear and vivid as normal vision/hearing”).

Participants were then asked if a subsequent stimulus was the same as or different from the one they had been asked to remember. Three different concurrent tasks were employed. In the control task, participants were asked to simply focus on the stimuli that were presented. In the tapping task, they had to press various keys in a pattern without looking down at them. In the counting task, they had to count aloud repeatedly from 1 to 10. Overall, it was found that when participants were required to utilize working memory, vividness ratings were impacted negatively if a concurrent task competed for similar cognitive resources; thus, the tapping task disrupted images held in the visuospatial sketchpad, while the counting condition disrupted those held in the phonological loop. Imagery vividness was also impacted by the amount of detail participants could recall from long-term memory. Thus, when tested with nonsense (vs. meaningful) or bizarre (vs. familiar) images, participants reported less vivid imagery. Baddeley and Andrade (2000) concluded that the vividness of information held in working memory depends on the richness of the representation.

The idea that long-term memory can interact with imagery is also captured in Lang's bioinformational theory of emotional imagery (Lang, 1979). Lang appeared to be fascinated by an individual's ability to form mental images, and how the ambiguity of words (which he denotes as propositions that others receive; see Kieras, 1978) could impact the pictures different individuals form within their *mind's eye*. He argued that mental imagery of an emotionally charged stimulus can have a similar impact as actually seeing the same stimulus in person, as it activates similar neural pathways. An individual could demonstrate that the image has been formed either verbally (by describing it) or non-verbally (via changes in physiological responses such as heart rate, respiration, muscle contraction, and skin conductance etc.). Consider the case of individuals who have a phobia of spiders. According to the theory, when asked to imagine a spider, these individuals not only activate stored information about spiders (e.g., regarding their appearance or the fact that they can bite you) but also the full range of bodily responses that those same people would have if they actually came into contact with a spider (racing heart, tensing muscles). It follows from Lang's theory that the use of fear extinction might be influential in treatment of specific phobias. This process involves retraining the body's response to the feared stimulus through the use of imaginal exposure, in a safe environment.

According to the bioinformational theory of emotional imagery, three distinct variables affect the top-down formation of emotional images: (1) being cued to form an image; (2) the nature of the cue (e.g., reading the word, watching a film clip); and (3) the role the individual is to play within the imagined scene (Lang, 1979). The interplay between these variables was explored in Experiment 2 of Lang et al. (1980). These authors had four groups of individuals listen to audio tapes of entire scripts that included information related to emotionally neutral, action, and fear-related scenes. Those in the first group, the stimulus group, were read passages

that included specific details about stimuli, and were reinforced for describing the stimuli. Those in the second group, the response group, were read passages that described physiological responses of the individual in the story and were reinforced when they recalled those experiences. Those in the third group were trained to focus on specific stimuli in the scene but were given the script describing the physiological responses. Finally, those in the fourth group were trained to focus on the physiological responses of the individual in the scene but were given the stimulus scripts. After each trial participants rated how fear-inducing and vivid the images they created were; physiological response data were also collected (i.e., heart rate, respiration, muscle contraction, and skin conductance). It was found that Group 2, the response group, experienced greater muscle contractions for action than for fear scripts, greater respiration responses for the fear than for action scripts (although this was reported to be less consistent), and faster heart rate for fear than for action scenes. This same pattern of results was not observed when training and script were incongruent. It was also found that, regardless of what script was read, the group that had response training experienced more vivid imagery than the stimulus trained groups. This was thought to reflect a tendency for those with response training to engage in motor or spatial imagery (representations of the placement of objects and the distance between them; see Blajenkova et al., 2006), recalling from long term memory the times when they experienced similar physiological responses as the individual from the script, instead of attending to the entire scene.

In addition to its links with long term memory, imagery and simulation/embodiment are also implicated in future thinking (FT), although the relationship may vary depending on one's cognitive style (e.g., whether one shows stronger object or spatial imagery). For example, work by Aydin (2018) explored how aspects of object and spatial imagery relate to the ability to recall

past events or to imagine possible future situations. Aydin (2018) suggested that object imagery positively correlated with the amount of sensory/perceptual detail, story coherence, and emotional valence of imagined past, but not future events. In contrast, spatial imagery was positively correlated with an individual's ability to recount episodic details of past and imagined future events. Recall, however, that Jeannerod (1994) also argued for a role for motor imagery in allowing us to place ourselves "in the action" (see above). Although beyond the scope of the current investigation, similar neural structures are recruited when remembering past events and when simulating possible future ones (see Schacter et al., 2008 for further discussion).

Individual Differences in Imagery and Simulation

There is a wide range in individuals' engagement in mental imagery/simulation and in the qualities of the images that are formed. At one end of this range are those with hyperphantasia, whom Pearson (2019) describes as having the ability to form mental pictures that appear life-like. At the other end are those who have aphantasia, which is formally defined as the inability to create mental imagery and a complete absence of imagination (Zeman et al., 2015).

In a study by Zeman et al. (2020), participants completed various questionnaires related to mental imagery. They found that participants who were hyperphantasic were more likely to work in jobs that involve creativity, whereas those who were aphantasic were more likely to work in analytic areas such as those involving computers, mathematics, and science. Additionally, the results suggested that aphantasic participants were less likely to experience dreams as visual images, instead reporting dreaming in more of a narrative style. Although Zeman et al. (2020) found that approximately half of aphantasic individuals in their sample experienced a complete deficit in imagery ability across all sensory modalities, some retained the ability to experience imagery through audition and a few reported preserved abilities in other

sensory modalities. This may explain why problems with auditory imagery have been reported in some studies of aphantasia (Dawes et al., 2020) but not others (Dance et al., 2021a). Finally, the researchers noted that many close relatives of aphantasic individuals also experience difficulty with visual imagery, suggesting a possible genetic link.

Dance et al. (2021b) argued that people who are good at mental imagery are also often very sensitive to incoming stimuli and vice versa. Moreover, Wicken et al. (2021) noted that those with intact visual imagery show a stronger fear response while reading scary stories compared to those with aphantasia, as measured by changes in skin conductance levels. It is currently unclear in the literature as to what may be underlying these findings. One potentially important variable may be sensory processing sensitivity (SPS). Aron et al. (2012) describe SPS as a heritable personality variable and note that individuals who score high on this trait show a heightened sensitivity to environmental stimuli, have a tendency to approach new stimuli with caution, are empathic and able to process incoming information at a deep level, and experience a “rich” inner life. Bröhl et al. (2022) provided further evidence for links between SPS and heightened emotional reactivity, a fondness for the music and the arts, and frequent daydreaming. In many respects, then, SPS seems to share features with hyperphantasia. Highly sensitive individuals also show high levels of activation in the mirror neuron system when viewing others (Ishikami & Tanaka, 2022; 2023). This system contains neurons that fire when one is performing or observing another performing an action. “Mirroring” the activation is thought to help individuals follow, replicate, and understand the actions of others (see Patel, 2024). This may help to explain why those with SPS report a strong ability to “put themselves in someone else’s shoes” and empathize with them (McQuarrie et al., 2023, 2025).

Another personality trait that may explain variance in mental imagery/simulation is alexithymia. Alexithymia is characterized by an externally oriented thinking style, and by difficulties identifying and describing one's own feelings (Nemiah et al., 1976). It has also been suggested that individuals with alexithymia suffer from an impairment in interoception that could impact embodiment (e.g., Murphy et al., 2018) and often report having an impoverished fantasy life (Sifneos, 1973). The latter suggestion gains support from a study by Peasley-Miklus et al. (2016), who tested the imagery abilities of alexithymic individuals through the use of an emotion script task. Participants who scored high or low on alexithymia listened to eleven 50 s long imagery scripts that could be emotionally valenced (angry, fearful, and joyful) or neutral. Individuals scoring high on alexithymia did not show greater heart rate fluctuations when trying to imagine emotionally valenced scripts compared to neutral scripts, whereas those scoring low on alexithymia did. The authors concluded that alexithymia was associated with a reduced capacity for imagery.

Recent work, however, suggests that impairments in interoception and fantasizing may not characterize all alexithymic individuals. Thus, alexithymic individuals who score low on externally oriented thinking score higher on a subjective measure of interoceptive accuracy (Jakobson & Rigby, 2021) and have richer inner lives (Jakobson et al., 2024) than those who score high on this facet of alexithymia. In the Jakobson et al. (2024) study, this link was mediated by SPS. The authors argued that, by turning their attention inward, members of this subgroup—who are more highly sensitive and emotionally reactive than alexithymic individuals who maintain a strong external focus—are better able to maintain strong representations of imagined events in working memory and more likely to fantasize.

Links Between Individual Differences in Mental Imagery/Simulation and Mental Health

In addition to their links with imagery and simulation, both SPS and alexithymia are associated with an increased risk of mental health problems such as anxiety and depression (e.g., Jakobson & Rigby, 2021; Suslow & Donges, 2017). Learning more about the role that atypicalities in visual and/or motor imagery might play in these relationships is important, as it could inform both theory and clinical practice. In their review paper on imagery measures and clinical psychology, Pearson et al. (2013) highlight how strong an impact mental imagery can have on a wide range of clinical psychopathologies including, for example, those related to anxiety (e.g., posttraumatic stress disorder or PTSD, see Holmes et al., 2007; social phobia, Morrison et al., 2011), and mood disorders (e.g., depression, Birrer et al., 2007; bipolar disorder, Holmes et al., 2008). Individuals with depression have been found to have a difficult time imagining a positive future (Pearson et al., 2015). The significance of imagery has also been seen in those struggling with suicidal ideation, where continually imagining a suicidal process can increase one's risk of a suicide attempt (Crane et al., 2012). Problems with embodiment and body perception have also been linked with negative mental health outcomes (Haggard & Wolpert, 2005), for example in those with anorexia nervosa (Fuchs, 2022) or schizophrenia (Rossetti et al., 2022).

Karaca Dinç et al. (2021) reported that both SPS and alexithymia mediate the relationship between exposure to childhood adversity or trauma and poor mental health. Although the extent to which atypicalities in imagery may explain these effects has not been thoroughly explored, some findings suggest that alexithymia and/or SPS, imagery (and related processes), and mental health do interact. For example, Putica et al. (2021) presented evidence that individuals who present with comorbid PTSD and alexithymia experience difficulty in accessing trauma-related

memories. Within the framework that Kosslyn (1980) proposed, these results might suggest that this deficit reflects an inability among those with alexithymia to generate and inspect mental images related to emotionally charged memories, such as those frequently associated with traumatic events. This could interfere with their ability to process these memories in therapy.

Other research suggests that highly sensitive individuals who have been exposed to adverse childhood experiences are not only at high risk of negative mental health outcomes (Aron et al., 2005) but also of experiencing vivid dreams and nightmares (Carr & Nielsen, 2017; Carr et al., 2021) that could be upsetting. It has also been reported that individuals who have experienced childhood trauma tend to engage in maladaptive daydreaming, becoming frequently engulfed in their own imagination for extended periods of time (Somer et al., 2021). The authors suggest that this may serve a protective function in these individuals in the short term, as it helps them avoid negatively valenced memories while focusing on more positive thoughts (e.g., an idealized family or relationship). However, it also reinforces a tendency for these individuals to escape or avoid stressful situations entirely (Soffer-Dudek & Somer, 2018). As a result, in the long term it may limit their ability to process the trauma and to build resiliency to stay present when their stress levels elevate. Given that maladaptive daydreaming is characterized by high degrees of fantasy proneness (Somer et al., 2016; Somer et al., 2017), it is possible that the use of this coping strategy is more common in individuals scoring high on SPS and low in features of alexithymia such as externally oriented thinking (EOT) (see Jakobson et al., 2024), although to my knowledge this has not been directly tested to date.

Overview of the Research

The research reviewed above is part of a broader literature that supports the view that

mental imagery is an important cognitive skill contributing to a range of functions including, for example, visual working memory, episodic memory, reading comprehension, planning, spatial orientation, and face processing (Aydin, 2018; Brunsdon et al., 2007; Guariglia & Pizzamiglio, 2007; Just et al., 2004; Kosslyn, 2005; Kosslyn et al., 1995; Palermo et al., 2008; Pearson, 2019; Pearson & Keogh, 2019). The focus of this dissertation is on motor imagery, mentalizing, and FT, all of which involve imagery/simulation and the operation of prediction mechanisms (Schacter et al., 2008). Each study included its own independent sample.

The first goal of the present dissertation was to examine factors that may explain individual differences in these imagery- and simulation-based processes. The research described in Chapter 2 examined individual differences in motor imagery using a paradigm used to assess participants' ability to make laterality judgements about hands shown in different orientations (a process thought to involve embodiment). The research described in Chapter 3 examined individual differences in biases affecting how images of faces are maintained in working memory using an emotion anticipation paradigm. Finally, the research described in Chapter 4 examined individual differences in aspects of FT. In each of the studies, the analyses undertaken allowed me to tease apart variance in these processes accounted for by SPS and alexithymia.

The second major goal of my planned research was to examine links between individual differences in imagery/simulation, personality, and mental health. This is important for theoretical reasons but, as suggested above, the findings may also have important clinical implications. For example, scoring high on visual imagery has been linked to experiencing more frequent involuntary (intrusive) memories (Vannucci et al., 2016) that can contribute to feelings of anxiety and depression. Imagery is also often used in psychological therapy and has been helpful in rehabilitation training (e.g., Boccia et al., 2019; Potvin et al., 2011). The research

described in this dissertation may inform how to tailor treatments for anxiety and depression to specific individuals on the bases of personality variables and deficits or strengths in imagery and/or simulation.

CHAPTER 2: EXPLORING INDIVIDUAL DIFFERENCES IN MOTOR IMAGERY AND THEIR LINKS TO MENTAL HEALTH

People vary in their use of imagery; however, it is currently unclear what may be driving this. Studying this is necessary for expanding our understanding of the processes involved and for refining the use of imagery-based techniques in sports training, rehabilitation work, and mental health interventions (Harris & Hebert, 2015; Malouin et al. 2013; Mizoguchi & Kanosue, 2017; Moran et al., 2015). In exploring this topic, it is important to consider that there are different types of imagery. Researchers have distinguished between object and spatial imagery, suggesting that both play important and unique roles in problem solving (Blazhenkova, 2016; Kozhevnikov et al., 2005). Object imagery has been referred to as pictorial, with the focus on the stimuli in the image and their physical characteristics (e.g., colour). Spatial imagery, on the other hand, captures how the stimuli within the image move around, interact, and control the environment. Distinct from these processes is motor imagery, which involves simulation of an action via recruitment of a similar neural network as that involved in actually performing it (Decety, 1996).

The main focus of the present investigation was on motor imagery. I assessed whether individual differences in motor imagery relate to the two personality traits that were the focus of this dissertation. I also explored whether performance in a task thought to provide an implicit measure of motor imagery was linked to self-reported levels of anxiety and/or depression, and whether these relationships persisted once variance related to the personality variables was controlled for. Below I provide background information about some of the past research that motivated my research.

Studying Motor Imagery Using the Hand Laterality Task (HLT)

The HLT is a popular paradigm for studying motor imagery. In this task, a single hand is presented at one of several different orientations across trials and the participant's job is to determine as quickly and as accurately as possible whether it is a left or right hand. Comparing performance on trials where the stimulus hand is rotated medially vs. laterally can help one determine whether an individual is using a motor imagery strategy (see de Lange et al., 2008; Parsons, 1994). This is because, when making actual movements, medial rotation of hands is accomplished more easily than lateral rotation, due to biomechanical constraints. If one sees a similar pattern during mental rotation (i.e., if it takes less time to make laterality judgments about hands that are rotated medially vs. laterally), it suggests that the person is mentally simulating the movement using a motor imagery strategy and is finding medially directed, simulated movements less "awkward." Such an effect has been reported in numerous studies (e.g., Parsons, 1987; Parsons, 1994; Sekiyama, 1982) and has been referred to in the literature as the medial-over-lateral advantage (MOLA; Funk & Brugger, 2008).

In a recent study, ter Horst et al. (2010) found that the MOLA was absent in a block that included only in-plane rotations of back views of hands (Set 1) but was evident in blocks involving both back and palm views rotated in-plane (Set 2) and/or in-depth (Set 3). They argued that the tendency to employ motor imagery varies as a function of the number of axes along which rotation can take place; however, they did not directly compare performance with back and palm views rotated in-plane. Others have shown that, with in-plane rotations participants show a clear mental rotation function but no MOLA when viewing back views, but their RTs are less impacted by angle of rotation and a MOLA is seen with palm views (e.g., Bläsing et al., 2013; Zapparoli et al. 2014). This suggests that viewers generally tend to apply spatial

transformation for back views but shift to the use of motor imagery for palm views even if rotation is confined to a single axis.

Zapparoli et al. (2014) had participants undergo fMRI while performing their HLT. Participants displayed stronger occipital activations when shown back views and stronger premotor and parietal activations when shown palm views. This interpretation is consistent with other work suggesting that spatial and motor imagery have somewhat different neural underpinnings (e.g., Borst, 2012; Hiew et al., 2023). Nonetheless, there was considerable overlap in the neural systems activated by both views. Zapparoli et al. (2014) suggested on these grounds that, regardless of the view shown, viewers adopt a viewer-centered perspective when making laterality judgments about hands but that the strategy they employ to solve the task varies depending on the view of the hand that is displayed. They argued that, because we are more familiar with back views (especially, perhaps, views of the right hand), we tend to use visuospatial transformation to make laterality judgments about these stimuli, but that with less familiar palm views motor simulation is more likely to be applied.

Individual Differences in HLT Performance

Like Zapparoli et al. (2014), Mibu et al. (2020) found that the largest MOLA was seen with the palm view of the right hand, overall. At the individual level, however, only 67% of their young adult sample showed a significant MOLA for right palm views, suggesting that motor imagery is not universally applied even when processing these stimuli. Interestingly, however, these authors also found that 22.2% of their sample showed a significant MOLA for right *back* views, suggesting that these individuals were using a motor imagery strategy.

More research is needed to explore factors that may drive individual differences in the use of motor imagery. One factor that appears to be relevant to strategy use is age. For example,

Bek et al. (2022) found that, compared to younger adults, older adults need more time to make laterality judgments, and both older adults and those with Parkinson's disease show larger MOLAs, overall. Nagashima et al. (2021) went on to show that, although motor imagery was *generally* used for palm views across all ages, middle aged and elderly individuals who found the HLT more difficult were more likely to apply motor imagery even when processing back views.

Sex may be another important variable to consider. Conson et al. (2020) found that males were faster than females at judging palms, whereas females were faster than males at judging back views. In addition, whereas both groups had significant MOLAs for palm views, females also showed a MOLA for back views as well, suggesting that they may apply motor imagery more broadly. I suspect that the latter finding may relate to the fact that females score higher than males on SPS (Aron & Aron, 1997; Benham, 2006; Van Landeghem & Jakobson, 2024). As noted in Chapter 1, individuals scoring high on this trait report heightened sensitivity to both environmental stimuli and body-based cues (De Gucht et al., 2022). They are also described as having “rich” inner lives (Aron et al., 2012) and often find themselves fantasizing (Bröhl et al., 2022) and imagining what characters in plays, books, and films might do, think, or feel—or how they themselves might react in similar situations (Jakobson et al., 2024). Those who frequently imagine complex scenes in which they or others are performing actions may be more likely to apply motor imagery when completing an HLT than those who are not fantasy prone—even when processing back views of hands.

Another personality trait that may contribute to individual differences in motor imagery is alexithymia. Alexithymia is characterized by difficulties identifying and describing one's feelings (Sifneos, 1973). Some individuals with alexithymia also adopt an externally oriented thinking style and report an impoverished fantasy life (Jakobson et al., 2024), interoceptive

deficits (e.g., Murphy et al., 2018), and atypicalities in motor mimicry (Franz et al., 2021; Nordmann et al., 2021) and embodiment (Laricchiuta et al., 2022). These latter characteristics might impact strategy use or performance in tasks such as the HLT. To my knowledge this has not been tested to date, but alexithymia has been shown to predict poor performance on Kessler's (2002) Facially Expressed Emotion Labelling (FEEL) test (Haas et al., 2013) which, in turn, is associated with low accuracy in making left/right judgements of facial postures (Von Piekartz et al., 2015). Moreover, in individuals with chronic unilateral face pain, participation in a multi-component therapy that included facial emotion recognition and graded motor imagery training led to improved accuracy of left/right facial posture judgements *and* to a reduction in symptoms of alexithymia (particularly EOT; Von Piekartz et al., 2022). Although these results suggest a link between alexithymia and impaired motor imagery, it is important to note that some individuals express features of both alexithymia and SPS (e.g., Jakobson & Rigby, 2021; Van Landeghem & Jakobson, 2024). Given this, it is important to try to isolate the unique variance in task performance that might be attributable to each of these traits.

Links to Mental Health

Motor imagery research may shed light on the clinical presentation and neurocognitive bases of common mental health problems, such as anxiety and depression. For example, Chen et al. (2013) found that individuals scoring high on depression performed the HLT more slowly than those who were not depressed, and Oshiyama et al. (2018) found that—in women—RTs on the HLT were positively correlated with both depression and anxiety. The link between RT and depression might reflect the slowed motor planning or psychomotor slowing that is considered to be a feature of the disorder (Wüthrich et al., 2022). The link with anxiety is consistent with the fact that anxious individuals take longer to make judgments across several categories of timed

experimental tasks—including those requiring spatial reasoning—compared to those not suffering from anxiety (Eysenck et al., 2007). Their hesitancy may be linked to SPS, which is characterized by a tendency to “pause to check” before responding when faced with uncertainty (Aron et al., 2012). It has also been suggested that anxiety depletes working memory resources (Maloney et al., 2014), which might be another factor that hampers performance.

In the study by Chen et al. (2013) mentioned above, participants with depression were found to have flatter mental rotation functions for hand stimuli and larger MOLAs than non-depressed individuals. This led the authors to suggest that depression may be associated with an alteration in how the body is represented or how movements are simulated. Unfortunately, MOLAs were not measured in the study by Oshiyama et al. (2018), so it is unclear from this study if larger MOLAs might also be associated with anxiety. It is also unclear whether relationships between task performance and these common mental disorders persist once levels of SPS and/or alexithymia—which are both risk factors for depression and anxiety; (e.g., Liss et al., 2005; Taylor & Bagby, 2004; Van Landeghem & Jakobson, 2024)—are controlled for.

The Current Study

The literature described above provides strong evidence for the use of the HLT task to assess an individual’s use of motor imagery. The first objective of the current study was to replicate the finding that motor imagery is generally applied in an HLT when processing palm views (e.g., Zapparoli et al., 2014; Bläsing et al., 2013). I expected to be able to show that performance on the HLT varied depending on the view of the hand shown, with a steeper mental rotation function being evident for judgments made regarding the back of the hand, and a larger MOLA being evident for judgments made regarding the palm. My design also allowed me to test for sex differences in task performance.

The second objective of this study was to assess possible links between performance on the HLT and both SPS and alexithymia. Because differences in individuals' responses to back and palm views were expected to be most marked when targets were rotated 120°, I focused on performance in this condition. Based on the literature reviewed above, I expected to find that stronger expression of SPS would be associated with larger MOLAs even when back views of the hand were shown. In addition, as past researchers have found that those scoring high on SPS will often “pause to check” before responding when faced with uncertainty (Aron et al., 2012), I expected to find that they would take longer to make their responses than those scoring low on this trait, regardless of the view of the hand that was shown. Given that individuals scoring high in alexithymia can show atypicalities in interoception (e.g., Murphy et al., 2018), motor mimicry (Franz et al., 2021; Nordmann et al., 2021) and embodiment (Laricchiuta et al., 2022), I expected to find that alexithymia scores would also be related to lower accuracy and/or to the size of the MOLA, although the likely direction of the latter effect was uncertain.

The third objective was to determine if an association between task performance in the most difficult condition (120° rotation) and the severity of symptoms of depression and/or anxiety persists when controlling for SPS and alexithymia, which are known risk factors for depression and anxiety (e.g., Liss et al., 2005; Taylor & Bagby, 2004; Van Landeghem & Jakobson, 2024). Consistent with earlier findings (Chen et al., 2013; Eysenck et al., 2007), I expected to find that RTs on correct trials would positively predict depression and anxiety, and that MOLA scores would positively predict depression. However, I also predicted that the relationships between task performance and these mental health indicators would be reduced in size after controlling for alexithymia and SPS. This would be expected if atypicalities in

simulation-based processes is just one feature of these traits that relate to increased risk for these common mental disorders.

Method

Participants

A convenience sample of undergraduate students was recruited from an Introduction to Psychology course at the University of Manitoba. After exclusions (see Data Cleaning and Statistical Analysis, below), the final sample included 134 individuals (75 female; $M_{\text{age}} = 19.2$ years, $SD = 2.3$). Given my interest in studying individual differences, the sample size exceeded that recommended by an a priori power analysis to detect a medium effect with power at .80 and an alpha of .05 in the planned regressions (G*Power 3.1.9.7). All but two participants confirmed they were right-handed. Participants gave informed consent and were compensated for their time with credit towards a research participation option in their course.

General Procedure

The data obtained for the current study were collected online using the Pavlovia platform (RRID: *SCR_023320*) for the experimental task and the Qualtrics Survey Platform (RRID: *SCR_016728*) for the questionnaires. The experimental task was programmed in PsychoPy (RRID: *SCR_006571*). After informed consent was obtained, participants completed the Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994), the Highly Sensitive Person Scale (HSPS; Aron, & Aron, 1997), the Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001), and the General Anxiety Disorder-7 (GAD-7; Spitzer et al., 2006), followed by the experimental task. The testing protocol was approved by the Research Ethics Board at the University of Manitoba, Fort Garry Campus.

Questionnaire Measures

Toronto Alexithymia Scale

The TAS-20 (Bagby et al., 1994) is a self-report measure of alexithymia. The 20 items fall into one of three subscales: (a) Difficulty Identifying Feelings (DIF; 7 items, e.g., *I am often confused about what emotion I am feeling*); (b) Difficulty Describing Feelings (DDF; 5 items, e.g., *I am able to describe my feelings easily*); and (c) Externally Oriented Thinking (EOT; 8 items, e.g., *I prefer talking to people about their daily activities rather than their feelings*). Responses are scored on a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). After reverse-scoring where indicated, responses are summed to produce a total score, which can range from 20–100. Bagby et al. (2020) recommend treating the total score as a continuous variable. In the present sample the TAS-20 had good internal consistency ($\alpha = .82$).

Highly Sensitive Person Scale

The HSPS (Aron & Aron, 1997) is used to measure SPS. Individuals indicate the degree to which each of 27 items applies to them using a 7-point Likert scale, ranging from 1 (*not at all*) to 7 (*extremely*). Responses on the scale are then averaged to compute an overall score, with higher scores representing stronger expression of the trait. An example item is *I seem to be aware of subtleties in my environment*. Lionetti et al. (2018) have argued that scores fall on a continuum across the general population. In the present sample the HSPS showed high internal consistency ($\alpha = .93$).

Patient Health Questionnaire-9

The PHQ-9 (Kroenke et al., 2001) is a 9-item measure of depression. The questions are based on the diagnostic criteria for major depressive disorder in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; American Psychiatric Association, 2000). For

example, one item relates to showing “little interest or pleasure in doing things.” Individuals indicate the degree to which they have experienced various problems within the past two weeks using a 4-point Likert scale, ranging from 0 (*Not at all*) to 3 (*Nearly every day*). Responses are then summed to compute a total score that can range from 0 to 27, with higher scores indicating more severe symptoms of depression. The PHQ-9 had high internal consistency in the current sample ($\alpha = .89$).

General Anxiety Disorder-7

The GAD-7 (Spitzer et al., 2006) is a 7-item measure of anxiety. The questions are based on diagnostic criteria for Generalized Anxiety Disorder from the fifth edition of the DSM (American Psychiatric Association, 2013). Individuals indicate the degree to which they have been bothered by certain feelings within the past two weeks, such as “feeling nervous, anxious, or on edge,” using a 4-point Likert scale, ranging from 0 (*Not at all*) to 3 (*Nearly every day*). Responses are summed to compute a total score that can range from 0 to 21, with higher scores indicating more severe symptoms of anxiety. The internal consistency for the GAD-7 in the current sample was excellent ($\alpha = .92$).

Experimental Task

This study employed an HLT. In each trial, participants were asked whether a single hand presented on screen was a left or right hand. Half of the participants of each sex completed this task followed by a second task used in a separate investigation, whereas the other half of the participants completed the two tasks in the reverse order. Each trial began with a fixation cross at the centre of the screen for 1000 ms, followed by a left or right hand that remained on screen until the participant indicated which hand was shown via a key press. Participants pressed one key with their right index finger to indicate that the right hand was shown and pressed another

key with their left index finger to indicate that a left hand was shown. RTs were captured. The stimulus hand was shown in either palm view or back view and was presented either upright (0 deg rotation) or rotated medially or laterally by either 60° or 120°. There was a total of 60 trials (3 repetitions X 2 views X 2 hands X 5 rotations). Prior to completing the experimental trials participants completed four practice trials.

Results

Data Cleaning and Statistical Analysis

In cases where a participant completed the study multiple times ($n = 5$), only the first attempt was retained and analyzed. Only correct trials were analyzed when assessing RTs for the HLT; however, correct trials that included RTs < 300 ms or > 3500 ms were excluded from all analyses as RTs in these ranges suggest anticipatory responses and poor effort, respectively. Respondents were excluded if they did not complete the behavioural tasks and/or one or more questionnaires or exhibited carelessness (no valid correct trials in one or more conditions; high error rates; quick questionnaire completion times; $n = 47$). This left a final sample of $N = 134$. There was 0.08% missing data across questionnaires. As questionnaire data were found to be missing completely at random, expectation maximization was used to estimate missing data before total scores were calculated. All statistical analyses were run in IBM SPSS Statistics (RRID: SCR_016479), version 29.

Objective 1: To Determine if Performance on the HLT Varies Depending on the View of the Hand Shown or Participant Sex

To explore the effects of angle of rotation (AOR) on accuracy, I conducted a 2 (Sex: Male, Female) X 2 (View: Back, Palm) X 3 (AOR: 0°, 60°, 120°) mixed ANOVA, collapsing across the hand shown. The within subjects factors were view and AOR, while the between

subjects factor was sex. Here and in subsequent ANOVAs Greenhouse-Geisser adjustments were made to the degrees of freedom, as needed, and significant main effects and interactions were followed up with tests of simple main effects, using Bonferroni corrections. I only observed a significant main effect of AOR [$F(1.8, 593.7) = 11.06, p < .001, \eta_p^2 = .077$] which suggested that (as expected) it was slightly harder to do the task at an AOR of 120° . However, performance was close to ceiling ($\geq 93\%$ correct) across all conditions; as a result, in subsequent analyses I focused only on the RT data.

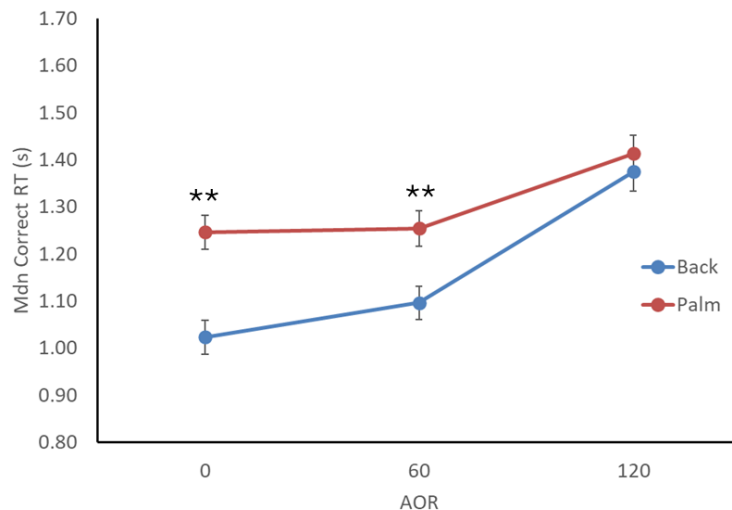
The second ANOVA took the same form as that described above but the dependent variable was median correct RT. Females' RTs [$M = 1.30$ s, $SE = .045$] were slower than males' [$M = 1.17$ s, $SE = .050$] overall [$F(1, 132) = 4.20, p < .042, \eta_p^2 = .031$], but sex did not interact with the other variables. There were significant main effects of view and AOR [$F \geq 44.093, p < .001, \eta_p^2 \geq .250$], but these had to be interpreted in light of a significant View X AOR interaction [$F(1.8, 242.4) = 15.33, p < .001, \eta_p^2 = .104$]. Tests of simple main effects confirmed that when making judgments of the back view of the hand participants took increasingly longer to respond as the AOR increased ($p < .001$ for all comparisons). The mental rotation function for palm views was flatter, with no difference between RTs at AORs of 0° and 60° ; participants also responded more slowly to palm than back views at these two AORs (Figure 2.1).

To compare the effects of direction of rotation (DOR), I ran a 2 (Sex: male, female) X 2 (View: back, palm) X 2 (AOR: $60^\circ, 120^\circ$) X 2 (DOR: medial, lateral) mixed ANOVA on the median correct RTs, collapsing across the hand shown. I observed significant main effects of sex, view, AOR, and DOR that had to be interpreted in light of significant View X AOR X DOR [$F(1, 132) = 11.056, p < .001, \eta_p^2 = .077$] and Sex X View X DOR [$F(1, 132) = 5.611, p = .019, \eta_p^2 = .041$] interactions. Follow-up tests on these two interactions confirmed that (a) the largest

MOLAs were seen with palm views rotated 120°; and (b) whereas males showed a MOLA for palm views, females showed MOLAs for both back and palm views (see Figure 2.2).

Figure 2.1

Response Times as a Function of Angle of Rotation and View of the Hand Shown

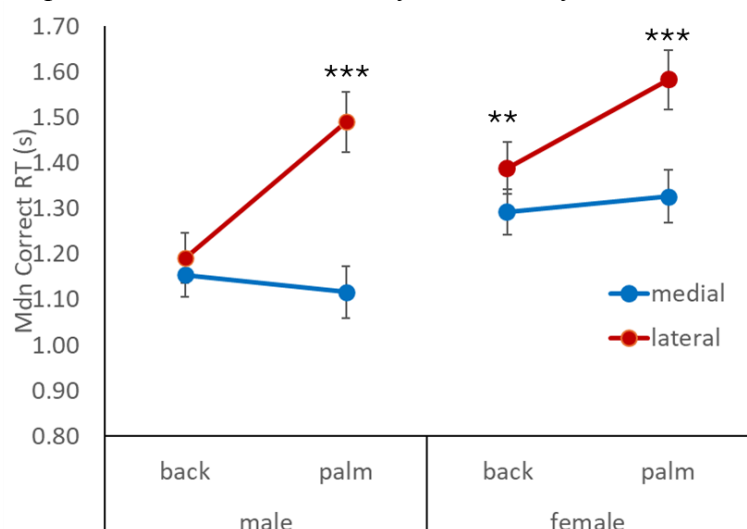


Note. Median correct response time (RT; SE indicated) at each angle of rotation (AOR) for back and palm views of the hand.

** $p < .001$ for the simple main effect of view.

Figure 2.2

Response Time as a Function of Direction of Rotation, View, and Sex



Note. Median correct response times (RTs; SE indicated) of males and females when responding to back and palm views of the hand shown rotated medially and laterally.

** lateral > medial, $p = .017$

*** lateral > medial, $p < .001$

Objective 2: Exploring the Relationships Between Performance on the HLT and Personality Variables

Given that the relationships between MOLA scores and the personality variables appeared to vary depending on the view of the hand shown in the full sample (see Table 2.1), I ran separate linear regressions for each view predicting the MOLA and the median correct RT in the most difficult condition (120° AOR). HSPS and TAS-20 total scores were entered as predictors using the forced entry method. In each analysis, bootstrapping was applied to estimate 95% CIs for the coefficients. In the first linear regression, HSPS positively predicted the MOLA for the back view of the hand, while TAS-20 did not. In the second regression, neither HSPS nor TAS-20 predicted the MOLA for the palm view. In the third and fourth regressions, HSPS predicted the median RT for the back and palm views of the hand, respectively, while TAS-20 scores did not (Table 2.2).

Table 2.1

Correlations Between Task Performance at 120° Rotation and Scores on Questionnaire Measures

	bRT	pRT	RT	bMOLA	pMOLA	TAS-20	HSPS	PHQ9
pRT	.772**	-						
RT	.946**	.936**	-					
bMOLA	.231**	.248**	.254**	-				
pMOLA	-0.015	0.066	0.026	0.11	-			
TAS-20	0.071	0.092	0.086	0.071	0.108	-		
HSPS	.220*	.236**	.242**	.237**	0.074	.447**	-	
PHQ9	0.152	.181*	.176*	0.115	0.117	.490**	.489**	-
GAD7	.219*	.263**	.256**	0.145	0.113	.557**	.537**	.736**

Note: Pearson correlations are shown between: response times (RTs) for the back view (bRT), palm view (pRT), and overall (RT); the size of the medial-over-lateral-advantage for the back view (bMOLA) and palm view (pMOLA); and scores on the Toronto Alexithymia Scale (TAS-20), Highly Sensitive Person Scale (HSPS), Patient Health Questionnaire (PHQ-9), and General Anxiety Disorder-7 (GAD-7) scores.

* $p < .05$ (2-tailed)

** $p < .01$ (2-tailed)

*** $p < .001$ (2-tailed)

Table 2.2

Relationships Between Personality Variables and Task Performance in the HLT at 120° Rotation

View		Predictors	MOLA at 120°			95% CI		Model Summary		
			<i>b</i>	<i>SE</i>	<i>p</i>	LL	UL	<i>R</i> ²	<i>F</i> (2,131)	<i>p</i>
Back		(Constant)	-.340	.239	.161	-.824	.127	.058	4.023	.020
		TAS-20	-.002	.005	.664	-.011	.007			
		HSPS	.126	.044	.006	.041	.212			
Palm		(Constant)	.139	.203	.529	-.258	.546	.013	0.831	.438
		TAS-20	.004	.006	.449	-.007	.014			
		HSPS	.015	.056	.800	-.083	.135			
View		Predictors	Mdn Correct RT at 120°			95% CI		Model Summary		
			<i>b</i>	<i>SE</i>	<i>p</i>	LL	UL	<i>R</i> ²	<i>F</i> (2,131)	<i>p</i>
Back		(Constant)	1.007	.217	<.001	.575	1.421	.050	3.415	.036
		TAS-20	-.001	.005	.743	-.011	.008			
		HSPS	.112	.045	.012	.025	.201			
Palm		(Constant)	1.022	.188	<.001	.652	1.385	.056	3.873	.023
		TAS-20	-.001	.004	.876	-.008	.007			
		HSPS	.107	.040	.009	.026	.181			
View	DOR	Predictors	Mdn Correct RT at 120°			95% CI		Model Summary		
			<i>b</i>	<i>SE</i>	<i>p</i>	LL	UL	<i>R</i> ²	<i>F</i> (2,131)	<i>p</i>
Back	Lateral	(Constant)	.804	.265	.004	.310	1.380	.083	5.947	.003
		TAS-20	-.002	.005	.649	-.013	.007			
		HSPS	.184	.050	<.001	.086	.280			
	Medial	(Constant)	1.144	.207	<.001	.733	1.547	.015	1.012	.366
		TAS-20	.000	.005	.932	-.010	.011			
		HSPS	.059	.048	.242	-.035	.147			
Palm	Lateral	(Constant)	1.061	.254	<.001	.539	1.526	.063	4.410	.014
		TAS-20	.002	.005	.719	-.008	.011			
		HSPS	.131	.048	.007	.040	.230			
	Medial	(Constant)	.921	.191	<.001	.554	1.319	.048	3.318	.039
		TAS-20	-.002	.005	.661	-.013	.007			
		HSPS	.116	.056	.044	.006	.224			

Note: HLT = hand laterality task; MOLA = medial-over-lateral advantage; HSPS = Highly Sensitive Persons Scale; TAS-20 = Toronto Alexithymia Scale; RT = response time (s). 95% confidence intervals (95% CIs) were based on 1000 bootstrap samples (LL = lower limit, UL = upper limit). Significant effects are indicated in bold.

Objective 3: Testing the Relationships Between Performance on the HLT and Mental Health

To determine if SPS and/or alexithymia accounted for additional variance in mental health once variance related to task performance was accounted for, I performed separate hierarchical regressions predicting depression and anxiety. In each analysis, bootstrapping was again applied to estimate 95% CIs for the coefficients. In the first step, I entered the mean correct RT and the MOLA at an AOR of 120° (collapsing across view) as predictors. In the second step, I entered total scores on the HSPS and the TAS-20.

The results are shown in Table 2.3. At Step 1, RTs on correct trials positively predicted severity of anxiety and there was a similar trend for mean MOLAs. There was also a trend for both performance variables to positively predict depression severity. The addition of HSPS and TAS-20 subscale scores at Step 2 improved the fit of both models greatly ($\Delta R^2 \geq .291$), with these two variables positively predicting severity of both anxiety and depression symptoms. Neither mean RTs nor mean MOLAs were related to either outcome variable once variance due to the personality variables was accounted for.

Discussion

The present study had three main objectives: 1) to replicate the finding that performance on the HLT varies depending on the view of the hand shown; 2) to explore the relationships between performance on the HLT and the personality variables of interest; and 3) to determine if there is an association between task performance in the most difficult condition of either task (120° rotation) and mental health (specifically, depression and/or anxiety) and, if so, whether this association was still evident when controlling for alexithymia and SPS.

Table 2.3

Relationships Between Overall Task Performance at 120° Rotation in the HLT and Mental Health Outcomes

DV		IVs	<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>F</i> (2,131)	<i>p</i>
						LL	UL		
Dep	<i>R</i> ² .046	(Constant)	6.486	1.888	.004	3.180	10.645	3.194	.044
		Mn RT	2.224	1.275	.073	-0.683	4.435		
		Mn MOLA	2.231	1.332	.085	-0.145	4.991		
	ΔR^2 .291	(Constant)	-9.804	2.736	<.001	-15.053	-4.236	16.411	<.001
		Mn RT	0.934	1.064	.371	-1.341	2.896		
		Mn MOLA	0.639	1.196	.604	-1.703	3.060		
		HSPS	0.196	0.042	<.001	0.113	0.276		
		TAS-20	1.986	0.502	<.001	0.842	2.915		
Anx	<i>R</i> ² .081	(Constant)	4.006	1.687	.013	0.891	7.475	5.812	.004
		Mn RT	3.151	1.156	.006	0.845	5.289		
		Mn MOLA	2.134	1.217	.072	-0.454	4.395		
	ΔR^2 .353	(Constant)	-12.882	1.939	<.001	-16.814	-9.149	24.765	<.001
		Mn RT	1.883	1.009	.060	-0.115	3.853		
		Mn MOLA	0.532	1.019	.593	-1.564	2.436		
		HSPS	0.215	0.035	<.001	0.140	0.283		
		TAS-20	1.874	0.396	<.001	1.153	2.720		

Note: HLT = hand laterality task. Dependent variables (DVs): Depression (Dep) = Patient Health Questionnaire-9; Anxiety (Anx) = General Anxiety Disorder-7. Mn RT = average of the Mdn correct response times across conditions; Mn MOLA = mean medial-over-lateral advantage; HSPS = Highly Sensitive Persons Scale; TAS-20 = Toronto Alexithymia Scale; 95% confidence intervals (95% CIs) were based on 1000 percentile bootstrap samples (LL = lower limit, UL = upper limit).

My first hypothesis was supported. Thus, like others (e.g., Bläsing et al., 2013; Zapparoli et al., 2014), I found that performance on the HLT did vary as a function of the view of the hand shown. Overall, participants showed a steeper mental rotation function for judgments made regarding the back (vs. the palm) view, supporting the conclusion that many individuals use spatial transformation to make their judgments about back views. They also showed a significant MOLA for palm views overall, suggesting that motor imagery is generally applied when making laterality judgments about these stimuli. Zapparoli et al. (2014) suggested that back views of the hand (especially those of the right hand) are likely seen more frequently than palm views

throughout a day (e.g., while eating, typing on a computer/laptop, or resting one's hands on a surface) and that our greater familiarity with them allows us to process them quickly and efficiently through the use of spatial transformation. They went on to suggest that, with less familiar palm views, motor imagery is generally required to solve the task.

I found that females responded more slowly than males overall and that, whereas males showed MOLAs for palm views, females showed MOLAs for both back and palm views. These findings are largely consistent with those of Conson et al. (2020), who found that (a) females were slower than males at judging palms, (b) females were faster than males at judging back views, and (c) whereas both groups had significant MOLAs for palm views, females also showed a MOla for back views. Given the results of the regression analyses (described below), I suspect that these findings may relate to the fact that females generally score higher on SPS than males (e.g., Aron & Aron, 1997; Benham, 2006; Van Landeghem & Jakobson, 2024).

The regression analyses addressed the question of whether performance on the HLT was related to SPS or alexithymia. Interestingly, my second hypothesis was partially supported as SPS predicted longer RTs on correct trials for both views. This is consistent with the fact that a characteristic of SPS is to respond cautiously, “pausing to check” before making a decision (Aron et al., 2012). As predicted, I also found that those scoring high on SPS showed larger MOLAs for back views than those scoring low on this trait, which would also have contributed to slower responding. That no such association was seen with palm views makes sense, if most people (regardless of their sensory sensitivity) adopt a motor imagery strategy to make judgments about palms. The finding that highly sensitive individuals appeared more likely to default to a motor imagery strategy even when a back view was shown was novel, and suggests that they may experience stronger embodiment and thus rely more heavily on motor imagery

than those scoring low on SPS to make their laterality judgments. SPS is normally distributed in the population, with about one-third of individuals reporting strong sensitivity (Lionetti et al., 2018). This may partially explain why Mibu et al. (2020) found that almost a quarter of their sample showed a significant MOLA for back views, particularly with right hand stimuli.

Individuals scoring high on SPS are said to have “rich” inner lives, characterized by frequent fantasies (e.g., Bröhl et al., 2022) and dreams (e.g., Schredl et al., 2020). It is likely that individuals who strongly express SPS traits frequently engage in motor imagery when they imagine or dream about themselves or others carrying out various actions. Past research suggests that people who focus on (auditory and visual) sensory information report more vivid motor imagery (Ikeda et al., 2012) and that vivid motor imagery, in turn, is linked to increased activation in the motor network (Olivetti Belardinelli et al., 2009) and the corticospinal pathway (Williams et al. 2012). This raises the possibility that, when processing back views in the HLT, individuals with SPS would show greater neural activation in areas that Zapparoli et al. (2014) found to be recruited during motor imagery (i.e., parietal and premotor regions) than those scoring low in SPS. In support of this, individuals scoring high in SPS have been shown to exhibit enhanced mirror neuron system activity when watching short videos of someone else grasping an object (Ishikami & Tanaka, 2023).

Contrary to my hypothesis, alexithymia was not directly related to RT-based measures of task performance when variance attributable to SPS was held constant. This may seem surprising as alexithymia has been characterized by an impoverished and limited fantasy life (Sifneos, 1973; Peasley-Miklus et al., 2016) and by atypicalities in interoception (e.g., Murphy et al., 2018), motor mimicry (Franz et al., 2021; Nordmann et al., 2021), and embodiment (Laricchiuta et al., 2022), which might lead one to expect that those scoring high on this trait would show

atypical task performance. However, Jakobson et al. (2024) argue that not all individuals with alexithymia fit this profile. Specifically, they suggest that people with alexithymia who not only score high on all three of the TAS-20 subscales but also on subscales of the HSPS that tap into sensitivity to feelings of discomfort are those most likely to have problems with multisensory integration and embodiment. It is these features of SPS that might contribute to atypical performance on the HLT. In contrast, alexithymic individuals who report difficulties identifying and describing their feelings but who are not externally oriented have been found to report frequent engagement in fantasizing (Jakobson et al., 2024). It is possible that they would be more likely to use motor imagery even when processing back views of hands.

The final set of hierarchical regressions that I ran partially supported my hypothesis that RTs on correct trials would positively predict depression and anxiety, and that MOLA scores would positively predict depression. I found that RTs on correct trials were predicted by anxiety in Step 1, consistent with earlier work showing links between task performance and mental health (Chen et al., 2013). The addition of the personality variables at Step 2 eliminated the trends observed at Step 1 for RT to positively predict depression. However, there was a trend for RT to continue to positively predict anxiety even after controlling for alexithymia and SPS, suggesting that the cautious approach taken by many highly sensitive individuals may not fully account for the link between slow responding and anxiety. Anxiety-related depletion of working memory resources (Maloney et al., 2014) might be another factor that hampers performance.

Trends were seen for MOLAs to positively predict both anxiety and depression at Step 1. I suggest that this may be because individuals with SPS appear to frequently use motor imagery for problem solving. Using motor imagery when imagining how one has acted in the past or how one might act in the future, particularly in negative scenarios, may contribute to the worrying and

rumination (characteristics of anxiety) and feelings of stress and tiredness (characteristics of depression) that are reported by many of those with SPS (Bas et al., 2021). Motor imagery may also play an important role in other phenomena, such as the “flashbacks” experienced by those with post-traumatic stress disorder (Moran et al., 2015). However, the fact that MOLAs were not significant predictors of anxiety or depression at Step 2, and that accounting for both SPS and alexithymia led to large improvements in model fit, suggests that features of these traits that are unrelated to motor imagery likely play an important role in these common mental disorders. For example, other work suggests that the risk for these poor mental health outcomes appears to be particularly high in highly sensitive or alexithymic individuals who were raised in unsupportive environments (Karaca Dinç et al., 2021). Other potentially relevant variables are discussed in subsequent chapters of this dissertation.

Strengths, Limitations, and Future Directions

The present study had many strengths, including the relatively large sample size and the use of an implicit measure of motor imagery and psychometrically sound self-report measures. Despite this, there were also some limitations. For example, although the HLT is commonly used in studies of this kind, the simultaneous collection of fMRI data (as in Zapparoli et al., 2014) would have allowed for an examination of the neural underpinnings of individual differences in motor imagery. It would also have been useful to supplement the HSPS with another measure, such as the Orienting Sensitivity subscale of the Adult Temperament Questionnaire–Short (Evans, & Rothbart, 2007), to capture additional features of SPS that may relate to task performance. Future researchers may also wish to examine whether individuals displaying different subtypes of alexithymia perform differently on the task. Lastly, as this study was completed online due to restrictions on in-person testing implemented to limit the spread of

COVID-19, the testing conditions were variable. Although Peyton et al. (2022) suggest that online testing did not create a major threat to the generalizability of findings during the pandemic, future researchers may wish to replicate these results using in-person testing.

Conclusions

The present study provides support for the idea that individuals scoring high on SPS tend to employ motor imagery more broadly than those scoring low on this trait, and that SPS may partially explain the relationship between performance on the HLT and anxiety and depression. I was unable to assess whether alexithymia might be related to less accurate performance in the HLT given that performance was essentially at ceiling. The present results suggest, however, that alexithymia is not associated with RTs. Although this was somewhat surprising, it is important to note that—unlike most other studies of alexithymia—SPS was controlled for in the present investigation. It is important to study alexithymia and SPS together as these traits can co-occur (e.g., Jakobson & Rigby, 2021; Van Landeghem & Jakobson, 2024).

It is important to learn more about the role that both motor imagery and personality play in mental health. Doing so may inform the development and tailoring of interventions for a range of mental health problems (e.g., Holmes et al., 2007; Moran et al., 2015). This topic will be further developed and discussed in Chapter 5.

CHAPTER 3: EMOTION ANTICIPATION EFFECTS

Imagery and working memory may serve different purposes. During music performances, for example, one may recruit the use of imagery to plan what a section of music should sound like or what movements are required to create the sound but working memory may be used to keep track of continued rhythm (Keller, 2012). Nonetheless, there is strong evidence to suggest overlap between visual imagery and working memory. For example, in an fMRI study conducted by Albers et al. (2013), they found that working memory and imagery rely on common visual representations (a finding also suggested by others, see Borst et al., 2012). Moreover, Keogh and Pearson (2011) found strong correlations between imagery strength and visual working memory performance.

There is an interesting body of research examining visual working memory for faces showing that images of some face stimuli are easier to maintain in visual working memory than others. For example, Thomas et al. (2014) found that expressively valenced faces, especially those displaying negative expressions (e.g., anger), are remembered more readily than neutral faces, suggesting that images of these faces are held in working memory more vividly. This reflects a negative memory bias where negative information is better consolidated than neutral or positive information (see Gaddy & Ingram, 2014; Matt et al., 1992). However, as these researchers did not measure imagery ability, or explore personality variables or other individual differences, it is unclear whether other factors may be driving this pattern of results.

Ekman (1993) suggests that it can be difficult to interpret static facial expressions, noting that someone can only make suggestions as to what another individual may be feeling. However, in everyday interactions, faces are rarely static; they are reactive, moving, and everchanging. Research has examined how we process and remember these more natural, dynamic expressions

(e.g., Marian & Shimamura, 2013; Van der Schalk et al., 2011; Yoshikawa & Sato, 2008), but much of this work focuses on the unfolding of expressions from neutral to apex.

Seeing an expression fade (e.g., from happy to neutral) can affect how the face is remembered. This was demonstrated in a series of experiments conducted by Palumbo and Jellema (2013). In their studies, participants were shown a sequence of static images showing a face moving from expressive to neutral. After the final frame, participants were asked to rate the expression that was just shown (the neutral face). In Palumbo and Jellema (2013) the same neutral stimulus face was evaluated differently depending on its *perceptual history* (i.e., on what expression preceded the neutral expression). For example, they found that the neutral expression was rated as slightly happy when the face was shown changing from an angry expression to neutral, but that the same neutral expression was rated as slightly angry when the face was shown changing from a joyful expression to neutral. This overshoot bias (OB) also affected sequences that stopped just before neutral (at 10% of the initial expression). For example, final frames showing 10% joyful faces were rated as significantly more angry than final frames showing 10% angry faces.

In Experiment 2 of Palumbo and Jellema (2013), they changed the identity of the person shown in the last frame. This manipulation was added to rule out the possibility that the OB was related to a low-level visual mechanism such as representational momentum (which involves extrapolation of implied motion) or a simple contrast effect (comparing the first and last frames). In either case, the fact that a new individual was shown in the last frame should not impact the bias. On the other hand, if the OB is due to a mentalizing process, changing the face's identity should eliminate the bias as the perceptual history would be discounted once the new stimulus face was presented. This was, in fact, what they observed. Based on these findings they

concluded that the OB represents an emotion anticipation (EA) effect that reflects the operation of a mentalizing mechanism viewers use to try to anticipate another's changing emotional state.

In Experiment 3, Palumbo and Jellema (2013) had the sequences loop from the neutral face to the expression's apex (100% expressive) and back to the neutral face. Again, an identity change was made in the final frame. In this case, a contrast effect would predict no bias (as first and last frames were the same), representational momentum would assume an OB (due to the implied motion), but EA would predict either no bias or an undershoot bias. The loop videos resulted in an undershoot response, providing further evidence that EA (mentalizing) underlies the effect.

Finally, in Experiment 4, Palumbo and Jellema (2013) were interested in how interrupting the flow of the sequence would impact the OB. They inserted a mask right before the final frame (the neutral stimulus face) was presented on screen. This manipulation did not impact the OB, suggesting that the bias did not reflect a simple adaptation effect. Taken together, these results suggested to Palumbo and Jellema (2013) that, although processing facial expressions requires bottom-up processing, anticipating the final emotional state of others may involve top-down processing and the operation of a low-level mentalizing mechanism.

The first objective of the current study was to replicate the EA effect. I expected neutral faces appearing at the end of joy-to-neutral sequences to be rated as slightly angry and neutral faces appearing at the end of anger-to-neutral sequences to be rated as slightly happy. If, however, an identity change was made in the final frame of a sequence, I expected to see a large drop in the size of the OB, supporting the conclusion that a mentalizing process is responsible for OBs seen in the identity-maintained condition.

I also wanted to determine if the size of observed OBs in the identity-maintained condition varied as a function of perceptual history or participant sex. If negative expressions have stronger representations in working memory (Thomas et al., 2014), OBs might be expected to be smaller for anger-to-neutral than joy-to-neutral sequences. If OBs reflect a mentalizing process, then they might be expected to be larger in females, who are thought to be better at mentalizing and more empathic than males (e.g., Baron-Cohen et al., 2001; Baron-Cohen & Wheelwright, 2004). It is important to note, however, that the sex difference in empathy is thought to be more evident in self-report than when indirect measures are used to assess sensitivity to others' emotional states (e.g., Eisenberg & Lennon, 1983).

My second objective was to determine whether SPS and/or alexithymia are directly or indirectly related to the size of OBs seen in the identity-maintained condition. Given the characteristics of these two traits, one might expect both to be directly related to size of OBs, although it seems likely that the precise relationships might vary as a function of the neutral face's perceptual history (fading joy vs. fading anger). To more fully capture aspects of SPS that relate to sensitivity to subtle cues, in this study I included the Orienting Sensitivity subscale of the Adult Temperament Questionnaire–Short (Evans, & Rothbart, 2007) as a secondary measure of SPS, as recommended by Aron et al. (2012).

Potential mediators of the link between my personality variables and OB size that I considered included vividness of imagery and the strength of *mentalizing tendencies*. That imagery vividness might be related to OB size is suggested by the fact that both alexithymia and *reduced* sensory sensitivity are related to aphantasia (e.g., Dance et al., 2021b; Monzel et al., 2024), which is associated with weak face recognition and memory (Dance et al., 2023). However, if Palumbo and Jellema (2013) are correct in suggesting that OBs are related to

mentalizing, then individual differences in mentalizing tendencies should be a better predictor of the size of OBs seen in the identity-maintained condition than individual differences in vividness of imagery. I quantified the strength of an individual's mentalizing tendency by assessing the impact that an identity change had on performance; this was reflected in the difference between ratings individuals gave to neutral faces in the identity-maintained and identity-changed conditions. As alexithymia is associated with deficits in mentalizing (Moriguchi et al., 2006), one might expect that scoring high on alexithymia would predict being less impacted by an identity change (as reflected in a smaller difference score). In contrast, as SPS is associated with strong emotion contagion and empathy (McQuarrie et al., 2023), one might predict that scoring high on SPS would predict being more impacted by an identity change (as reflected in a larger difference score). In either case, I expected to find that, although both mentalizing tendencies and vividness of imagery would be related to my personality variables and OB size, the strength of one's mentalizing tendency would be the stronger mediator of the link between these variables.

My third objective was to determine if anxiety and depression are directly or indirectly related to the size of OBs in the identity-maintained condition. This is of interest given reports that depression and anxiety are characterized by an exaggerated negativity bias (such that negative stimuli are processed more efficiently than positive stimuli). For example, research has shown mood congruent processing biases for facial expressions and negatively valenced stimuli (e.g., Bourke et al., 2010; Elliott et al., 2002) and a reduced positivity offset (specifically, a reduced tendency to evaluate neutral stimuli positively) (Bourke et al., 2010; Gollan et al., 2016; Weldon et al., 2023) in depression. In addition, Grupe and Nitschke (2013) describe a bias in anxious individuals to perceive ambiguous stimuli as dangerous or threatening. They argued that

the impact of anxiety on decision-making is related to how much information an individual has regarding a situation. During times when a negative outcome is possible (even if this possibility is unlikely), anxious individuals may inflate the probability of the event being negative and experience an increase in distress.

To my knowledge, there is no research that has examined how individuals with anxiety or depression may respond when completing an EA task. However, the findings reviewed above suggest that individuals reporting clinically significant signs of anxiety or depression may show a negativity bias. That is, compared to individuals not experiencing anxiety or depression, they may show larger OBs for joy-to-neutral than anger-to-neutral sequences in the identity-maintained condition. To test this, I compared participants who were reporting signs of moderate-to-severe symptoms of each of these common mental disorders to participants who were not on their task performance.

I also sought to determine if any observed link between mental health and the size of the OB seen with joy-to-neutral sequences varied as a function of individual differences in personality. It seems likely that this might be the case, given that alexithymia and SPS have often been associated with negative mood states such as depression and anxiety (e.g., Jakobson & Rigby, 2021; Suslow & Donges, 2017; Van Landeghem & Jakobson, 2024), and both traits have also been linked to other potentially relevant cognitive biases. For example, alexithymia has been shown to be associated with hostile attribution bias, in which ambiguous facial cues are interpreted as threatening (Li et al., 2020), and both alexithymia (Lumley et al., 2002) and SPS (Yano & Oishi, 2024) are associated with catastrophizing (i.e., the tendency to assume the worst, often exaggerating possible negative consequences in a given situation). It seems possible on these grounds that strong endorsement of particular features of these traits might mediate links

between anxiety and/or depression and the size or direction of OBs in the identity-maintained condition.

Work in our lab has suggested that SPS is associated with strong emotion contagion and empathy (McQuarrie et al., 2023), which might mean that those scoring high on SPS (i.e., more empathic) might interpret ambiguous facial expressions as signs of distress and give them more negative ratings. The tendency to evaluate them more negatively might also reflect the cautious responding (i.e., assuming ambiguous facial expressions are negative) that has been described in those scoring high vs low on SPS (Aron et al., 2012).

My final objective was to determine if accounting for information about these personality traits captures unique variance in anxiety and depression, beyond that accounted for by EA effects. I expected to find that this would be the case, given that these traits are linked to other difficulties (e.g., problems with emotion regulation; Edwards & Wupperman, 2016; Liu & Tian, 2024; Preece et al., 2019) that could also contribute to these mental health issues.

In summary, in the present study I tested several hypotheses. The first was that OBs for joy-to-neutral and anger-to-neutral sequences would reflect the operation of a mentalizing (EA) effect, and potentially be larger for joy-to-neutral sequences and in females (H1). The second was that alexithymia would predict smaller overshoots and that OS would predict larger overshoots in the identity-maintained condition, and that these effects might be more strongly mediated by mentalizing tendencies than by imagery vividness (H2). The third was that anxiety and depression would predict larger OBs for fading joy sequences and smaller OBs for fading anger sequences, and that the link between these variables might be mediated by personality traits (H3). Finally, I predicted that SPS and alexithymia would make independent contributions

to predictions of anxiety and depression after accounting for OBs seen in the experimental task (H4).

Method

Participants

After exclusions (see Data Cleaning, below), this study included a convenience sample of 145 undergraduate students (75 female, 69 male, 1 prefer not to say) recruited from the Introduction to Psychology subject pool at the University of Manitoba. This provided sufficient power to detect a medium effect in our planned ANOVA and regressions with power set to .80 (G*Power 3.1.9.7) and was expected to provide sufficient power for the tests of mediation (based on Sim et al., 2021). Participants gave informed consent and were compensated for their time with credit towards a research participation option in their Introduction to Psychology course.

Methods and Procedure

General Procedure

The data obtained for the present study were collected online using the Pavlovía platform (RRID: SCR_023320) for the experimental task and the Qualtrics Survey Platform (RRID: SCR_016728) for the questionnaires. The experimental task was programmed in PsychoPy (RRID: SCR_006571). After informed consent was obtained, participants completed the experimental task, followed by the TAS-20, the HSPS, the OS, the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973), the PHQ-9, the GAD-7, and the Conscientious Responders Scale (Marjanovic et al., 2014). Descriptions of several of these measures appear on pp. 22-23; below, I present descriptions for the measures unique to the present study only. The testing protocol was approved by the Research Ethics Board at the University of Manitoba, Fort Garry Campus.

Experimental Task

Facial stimuli for the experimental task were obtained from the Amsterdam Dynamic Faces Expression set (Van der Schalk et al., 2011). This set includes 648 videos of models displaying positive and negative emotions. Single frames depicting the apex of each expression and a neutral expression for each model are included in the set. I selected from these images frames that portrayed the apex for joy, the apex for anger, and a neutral expression for each of six female and six male models. Using the apex image for joy and the neutral image for a given model, I then created a series of nine intermediate images (depicting the target emotion at values ranging from 90% to 10% of the apex expression) using a morphing program called FantaMorph 5 (<https://www.fantamorph.com/>). When presented in order, each image sequence depicted the expression smoothly resolving from its apex to neutral. This process was then repeated using the apex image for anger for that same model. The 10-images that began each sequence provided the perceptual history for the neutral face that followed. Sequences featuring two male and two female models were used in practice trials, and those featuring the remaining four male and four female models were used in the experimental trials.

E-Prime software (<https://pstnet.com/products/e-prime/>) was used to present the experimental stimuli to participants. Before the experimental trials began, participants were presented with 16 calibration trials in which they viewed an image of each of the four female and four male models who appeared in the experimental trials displaying a neutral expression. Each image was shown twice. These trials began with a 500 ms fixation cross followed by the test image, which was shown for 600 ms. During these trials, participants rated the valence of the expression shown on a 5-point Likert scale ranging from 1 = *slightly angry* to 5 = *slightly happy*. Responses were entered via a key press. The purpose of the calibration trials was to obtain a

baseline rating for each participant of the neutral face of each model, shown with no perceptual history.

Following the calibration trials, participants completed two counterbalanced blocks of trials, each preceded by eight practice trials. The sequences in the practice trials featured both joy and anger perceptual histories for male and female models not in the experimental stimulus set. The identity of the model whose neutral face was shown at the end of each sequence either matched that shown in the perceptual history (identity-maintained condition) or differed from it (identity-changed condition). The sex of model whose neutral test face was shown in the identity-changed condition could be either the same or different from that of the model shown in the perceptual history.

Each experimental block included 64 randomly ordered trials. In the identity-maintained condition, there were four joy-to-neutral and four anger-to-neutral trials featuring each of the eight models. The identity-changed condition was similar, except that the final frame in each trial showed the neutral expression of a different model. Across trials in the identity-changed condition this final (test) face could be either of two female models or either of two male models, all chosen to ensure that their eyes aligned with those of the model appearing in the perceptual history sequence (i.e., eye level was kept consistent when an identity change was introduced). In both blocks, each model appeared an equal number of times (a) in each type of perceptual history sequence, and (b) in the final (test) frame.

Each trial began with a fixation cross in the center of the screen for 500 ms, followed by the first frame (the peak of the expression) for 300 ms, the intermediate frames for 30 ms each, and the final (test) frame for 300 ms. After the final image in the sequence disappeared, the participant was asked to rate the valence of the expression shown in that frame using the 5-point

scale described earlier. The exact size of the stimuli varied depending upon the resolution settings on participants' monitors but was held constant for a given participant. Participants were told to respond as quickly and as accurately as possible.

Self-Report Measures Unique to the Study

Orienting Sensitivity Index. Aron et al. (2012) have encouraged the use of the OS (Evans & Rothbart, 2007) as a supplementary measure of SPS. The OS is a 15-item measure that is responded to on a 7-point Likert scale, ranging from 1 = *Extremely untrue of you* to 7 = *Extremely true of you*. A *not applicable* response option is also available but in the standard scoring protocol these responses are treated as missing data that are replaced with the mean score for relevant items from the full sample. Scores on the OS are summed to yield a total score that can be broken down into three subscales. Neutral Perceptual Sensitivity (NPS; five items), which measures awareness of bodily and environmental stimuli of low intensity (e.g., "I'm often aware of the sounds of birds in my vicinity"). Affective Perceptual Sensitivity (APS; five items), which measures awareness of how subtle environmental cues impact mood (e.g., "When I am listening to music, I am usually aware of subtle emotional tones"). Associative Sensitivity (AS; five items) measures problem-solving, vivid imagery, and dreaming—i.e., processes that are not driven by stimuli in the immediate environment (e.g., "I sometimes seem to understand things intuitively"). Inclusion of the AS items allows one to capture information about the extent to which the respondent engages in "deep" processing and experiences a "rich" inner life, which are features of SPS not measured by the HSPS. The internal consistency of the OS in the present sample was acceptable ($\alpha = 0.74$).

Vividness of Visual Imagery Questionnaire. The VVIQ (Marks, 1973) is a 16-item measure used to assess vividness of visual imagery. Participants are asked to indicate how vivid

their mental imagery is related to four categories: (a) a person they frequently see; (b) a sunrise; (c) a place they shop at; and (d) a country scene with trees, mountains, and a lake. Each category contains four specific scenes (e.g., for the sunrise category one scene is “The sun is rising above the horizon into a hazy sky”). Each item is responded to on a 5-point Likert scale, ranging from 1 = *No image at all, you only “know” that you are thinking of the object* to 5 = *Perfectly clear and lively as real seeing*. A total score is then computed where higher scores indicate more vivid mental imagery. The VVIQ had excellent internal consistency in the present sample ($\alpha = 0.94$).

Conscientious Responders Scale. The Conscientious Responders Scale (Marjanovic et al., 2014) is a 5-item measure used to detect poor effort in individuals completing self-report measures. Each item has a correct answer (e.g., “To answer this question, please choose option number four, “neither agree nor disagree”), which allows one to determine whether particular instructions are being followed or not. The items are randomly distributed throughout all other measures. Committing three or more errors on these items is taken as evidence of poor effort. The Conscientious Responders Scale has been shown to distinguish conscientious from random responding with high accuracy (Marjanovic, et al., 2014).

Results

Data Cleaning and Statistical Analysis

The initial sample included 187 respondents. Only the first attempt was retained for anyone who completed the experiment online twice. In the experimental task, all trials in which participants’ RTs were either < 250 ms or > 3000 ms were removed from analysis due to the likelihood that these out-of-range values reflected anticipatory responses or poor effort, respectively. All trials depicting one of the male models were excluded from the means for both conditions because his neutral expression was judged to be quite angry ($M_{\text{calibration}} = 1.49$, $SD =$

.64). In addition, when computing a given individual's mean response, three conditions had to be satisfied. First, trials featuring any other model whose face triggered out-of-range RTs for either one or both conditions were excluded from the calculation for both conditions. This ensured that comparisons between performance in the two conditions were always based on trials featuring the same models. Second, participants had to have completed both conditions and had to have RTs in the acceptable range for trials featuring at least two models of each sex per condition. Finally, participants were removed from analyses if they made more than two errors on the Conscientious Responders Scale or failed to complete any of the questionnaires. In total, 42 participants were removed for one or more of the reasons noted above, leaving a final sample size of 145.

Missing responses to any questionnaire items in the final sample were found to be missing completely at random and were estimated using an expectation maximization procedure before subscale or total scores were calculated. All statistical analyses were run in IBM SPSS Statistics (RRID: *SCR_016479*), version 29. Prior to running analyses, I winsorized the data as needed by replacing values more than 3 *SD* from the mean with the next acceptable value. The resulting variables were approximately normally distributed.

Correction for Perceptual Bias

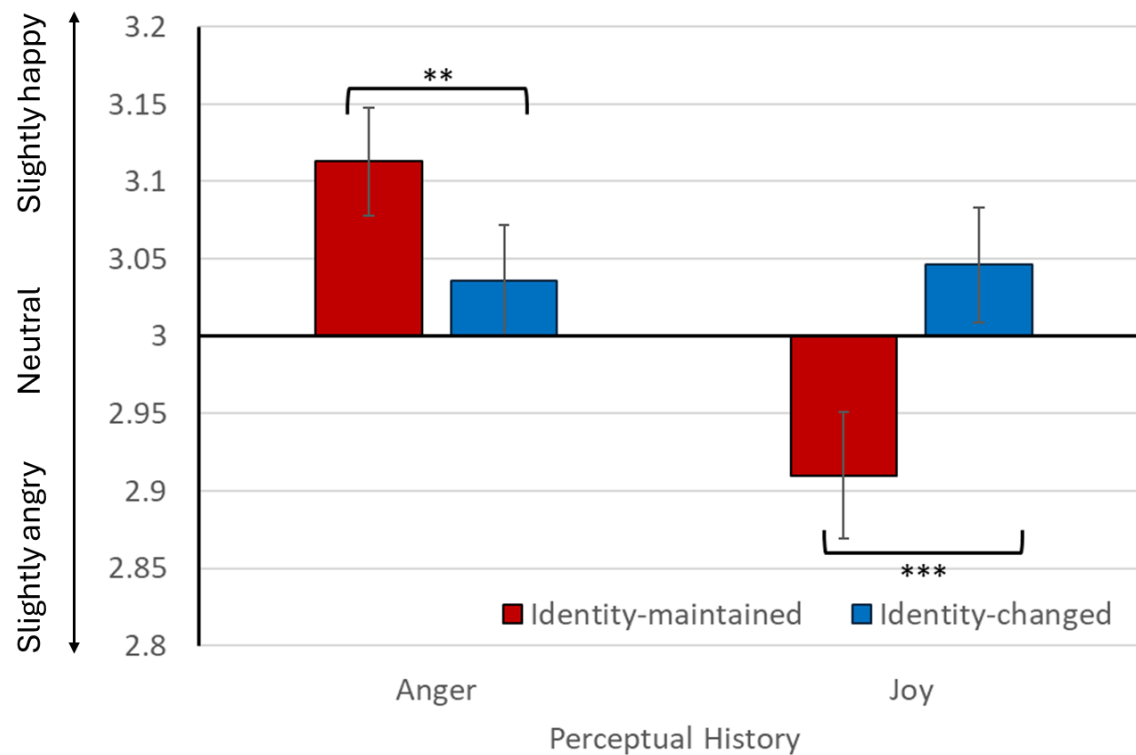
First, data from the calibration trials that each participant completed were used to compute corrected ratings for the experimental trials comprising each block. To obtain the corrected ratings, the mean of a participant's rating of each neutral face in the calibration phase was subtracted from a neutral rating of 3. Once this was done, the difference score for each model was added to the mean rating for that model's neutral face when shown at the end of a stimulus sequence. The purpose of making this correction is to account for any bias that

participants may have had when observing and evaluating neutral faces seen in isolation (without a perceptual history). The corrected ratings were the dependent variables in the analysis section described below.

Objective 1: Testing for EA Effects

To test for EA effects, I conducted a 2 (Sex: Male, Female) X 2 (Perceptual History: Joy/Anger) X 2 (Identity: Maintained/Changed) mixed ANOVA. The within subjects factors were Perceptual History and Identity, and the between subjects factor was participants' sex assigned at birth. Greenhouse-Geisser adjustments were made to the degrees of freedom, as needed, and significant main effects and interactions were followed up with tests of simple main effects, using Bonferroni corrections. One individual who did not specify their sex was excluded from this analysis, leaving a sample of $n = 144$.

I observed a significant Identity X Perceptual History interaction [$F(1, 142) = 29.079, p < .001, \eta_p^2 = .170$]. Tests of the simple main effect of identity at each level of perceptual history confirmed that the neutral face appearing at the end of anger-to-neutral sequences was rated as more joyful in the identity-maintained condition than in the identity-changed condition ($p = .006$). Conversely, the neutral face appearing at the end of joy-to-neutral sequences was rated as angrier in the identity-maintained condition than in the identity-changed condition ($p < .001$). Tests of the simple main effect of perceptual history at each level of identity revealed that there was a significant difference between ratings of neutral faces appearing at the end of angry and joyful sequences in the identity-maintained condition ($p < .001$), but not in the identity-changed condition ($p = .838$). (See Figure 3.1.) There was no main effect of sex and there were no interactions involving this factor. As such, sex differences were not considered further.

Figure 3.1*Mean Ratings of Neutral Faces Under Different Testing Conditions*

Note. Mean ratings (SE indicated) of the final neutral face shown at the end of anger-to-neutral (Anger) and joy-to-neutral (Joy) sequences in each testing condition.

To determine if there was a significant OB in either condition, I conducted one-tailed, one sample t-tests comparing the corrected mean rating for each type of sequence to a “neutral” rating of 3. In the identity-maintained condition, significant OBs were observed. Thus, ratings of faces appearing at the end of anger-to-neutral sequences appeared slightly happy [$t(143) = 3.243$, $p < .001$, $d = .42$] and those appearing at the end of joy-to-neutral sequences appeared slightly angry [$t(143) = -2.151$, $p = .017$, $d = .50$]; both effects were of medium size. In contrast, in the identity-changed condition, angry and joyful sequences did not differ significantly from neutral.

Taken together, these findings support the view that, generally speaking, overshoots seen in the identity-maintained condition reflect the operation of an emotion anticipation (mentalizing) effect, as expected.

Descriptive Statistics and Zero-order Correlations

For illustrative purposes, descriptive statistics and zero-order correlations between the self-report variables and select performance variables are summarized in Table 3.1. As expected, TAS-20 and HSPS scores were positively correlated; HSPS and OS scores were positively correlated; and all three personality variables were positively correlated with both mental health variables, with small-to-large effect size. In addition, as expected, scores on the OS scale were positively associated with VVIQ scores, with medium effect size.

Objective 2: To Determine if SPS and/or Alexithymia are Directly or Indirectly Related to the Size of OBs Seen in the Identity-maintained Condition

I ran separate multiple regressions predicting ratings for neutral faces shown at the end of joy-to-neutral and anger-to-neutral sequences in the identity-maintained condition. TAS-20, HSPS, and OS were entered as predictors using the forced entry method, and 95% confidence intervals were estimated based on 1000 bootstrap samples. The overall models predicting ratings of the neutral faces at the end of both types of sequences were not significant, suggesting that there were no direct relationships between personality and OBs seen in this condition.

I next set out to determine whether enhanced mentalizing and/or more vivid imagery mediated the link between OS and OBs for joy-to-neutral seen in the identity-maintained condition. To get an index of individual differences in “mentalizing tendencies,” I computed differences in ratings of neutral faces in the two conditions, for each type of sequence. For

Table 3.1*Descriptive Statistics and Zero-order Correlations*

	<i>M</i>	<i>SD</i>	TAS-20	HSPS	OS	VVIQ	PHQ9	GAD7	Ang	Joy	AngMT
TAS-20	53.6	11.3	--								
HSPS	4.4	0.8	.376***	--							
OS	5.0	0.8	-.037	.386**	--						
VVIQ	60.3	13.0	-.001	.002	.303***	--					
PHQ9	11.0	6.1	.454***	.417***	.265***	-.032	--				
GAD7	8.4	5.9	.516***	.587***	.286***	.099	.722***	--			
Ang	3.1	0.4	-.073	.106	.102	.046	.010	.039	--		
Joy	2.9	0.5	.019	-.065	-.178*	.081	-.062	-.002	.100	--	
AngMT	0.1	0.3	.081	.052	.065	.160	.052	.041	.370**	.134	--
JoyMT	0.1	0.3	-.036	.089	.241**	.048	-.033	-.009	.133	-.531***	.055

Note: Toronto Alexithymia Scale (TAS-20), Highly Sensitive Person Scale (HSPS), Orienting Sensitivity (OS) subscale of the Adult Temperament Questionnaire, Vividness of Visual Imagery Questionnaire (VVIQ), Patient Health Questionnaire-9 (PHQ9), General Anxiety Disorder-7 (GAD7) scale, mean rating for neutral faces at the end of anger (Ang) and joy sequences (Joy) in the identity-maintained condition; difference between ratings of neutral faces in the anger-to-neutral sequence in the identity-maintained and identity-changed (AngMT); difference between ratings of neutral faces in the joy-to-neutral sequence in the identity-changed and identity-maintained tasks (JoyMT).

** $p < .010$ (2-tailed)

*** $p \leq .001$ (2-tailed)

sequences beginning with an angry expression, I subtracted the rating in the identity-changed condition from that in the identity-maintained condition, as ratings were predicted to be higher in the former. For sequences beginning with joyful expressions I did the reverse, as ratings in the identity-changed condition were predicted to be higher. This meant that, regardless of the direction of the overshoot, a larger mentalizing index reflected a larger OB (in the predicted direction) when identity was maintained vs. changed. Interestingly, these scores were twice as large for joy-to-neutral compared to anger-to-neutral sequences, $t(144) = -1.754$, $p = .041$ (one-tailed), $d = 0.466$, suggesting that the tendency to anticipate a negative shift in another's mood was stronger than the tendency to anticipate a positive shift in another's mood in my sample.

The zero-order correlations presented in Table 3.1 showed that OS (but not HSPS or TAS-20) scores were related to two of the proposed mediators—mentalizing when processing joy-to-neutral sequences and VVIQ scores. As such, I ran a mediation analysis using PROCESS model 4 in SPSS, entering OS as my predictor, mean ratings for neutral faces in joy-to-neutral sequences as my outcome variable, and the mentalizing index associated with these sequences and VVIQ scores as parallel mediators. Due to my limited sample size, TAS-20 and HSPS were not entered as covariates. In the analysis, the significance of the indirect effects was assessed by examining percentile bootstrap confidence intervals based on 5000 bootstrap samples. OS scores predicted scores on both the VVIQ ($a_1 = 4.872$ [2.342, 7.402]) and the mentalizing index ($a_2 = .103$ [.035, .172]). In addition, full mediation via mentalizing was supported ($a_2b_2 = -.0775$, bootstrap 95% CI[-.153, -.018]). These results should be interpreted cautiously but provide some preliminary support for the idea that the relationship between OS and an increased tendency to perceive neutral faces as “slightly angry” is mediated by individual differences in the tendency to engage mentalizing when processing sequences showing fading joy.

Objective 3: Determining if Those Reporting Significant Anxiety or Depression Exhibit a “Negativity Bias” in Task Performance

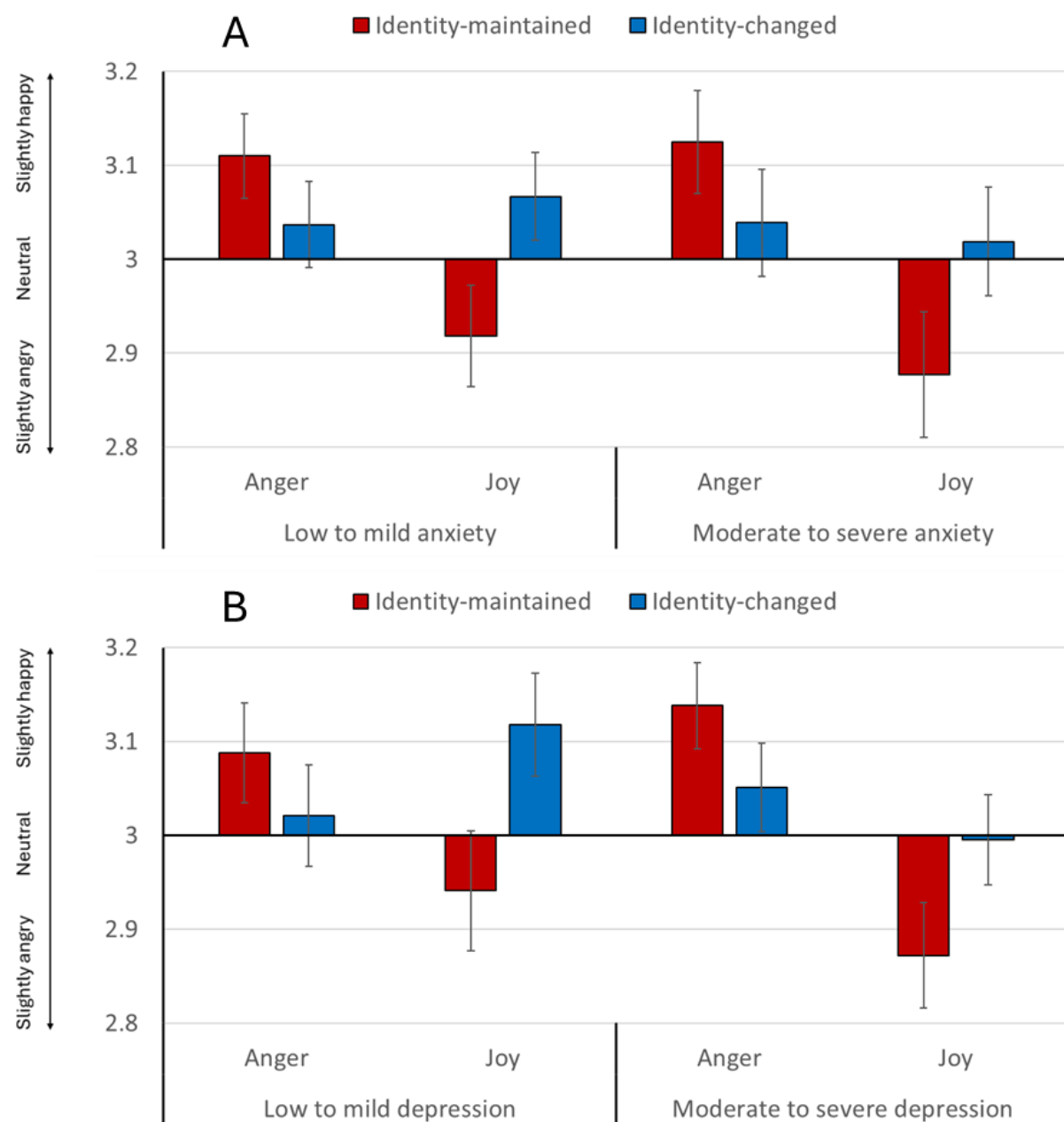
To address this question, I first looked for evidence of differences in task performance by conducting two separate 2 (Symptom Severity: none-to-mild, moderate-to-severe) x 2 (Condition: Identity-maintained, Identity-changed) x 2 (Perceptual History: Joy, Anger) mixed ANOVAs. The first ANOVA compared groups based on severity of anxiety symptoms, while the second ANOVA compared groups based on severity of depression. Group membership was determined based on standard cutoffs for the PHQ-9 (Kroenke et al., 2001) and the GAD-7 (Spitzer et al., 2006). Greenhouse-Geisser adjustments were made to the degrees of freedom, as needed.

Both ANOVAs revealed a significant main effect of Perceptual History [$F(1, 143) \geq 4.029, p \leq .047, \eta_p^2 \geq .035$] and a significant Condition X Perceptual History interaction [$F(1, 143) \geq 28.735, p < .001, \eta_p^2 \geq .167$] but no main effect or interaction involving the grouping factor. These results suggest that, contrary to expectations, the groups performed similarly overall (see Figure 3.2).

As a final step, I wanted to determine if the link between mental health and the size of the OB seen with joy-to-neutral sequences varied as a function of individual differences in OS. To answer this question, I ran two separate mediation analyses using PROCESS model 4 in SPSS, entering the ratings for joy-to-neutral sequences as my predictor, the OS score as the mediator, and either the GAD-7 or the PHQ-9 score as the outcome. The significance of the indirect effects was assessed by examining percentile bootstrap confidence intervals based on 5000 bootstrap samples. Full positive mediation was supported in both analyses (see Table 3.2). Although causal conclusions cannot be drawn from these analyses, the findings are consistent with the suggestion

Figure 3.2

Mean Ratings of Neutral Faces as a Function of Severity of Self-Reported Anxiety or Depression



Note: Mean ratings (SE indicated) of the final neutral face shown at the end of anger-to-neutral joy-to-neutral and sequences during the identity-maintained and identity-changed conditions in groups reporting differing levels of severity in symptoms of anxiety (A) and depression (B).

that the tendency to anticipate a negative shift in another's affective state when the perceptual history shows fading joy is linked to mental health problems *in individuals who score high (vs. low) on orienting sensitivity*. This result, then, provides qualified support to my hypothesis.

Table 3.2

Mediation of the Link Between Severity of Anxiety/Depression and Overshoots Associated with Processing of Joy-to-neutral Sequences

DV	M	Effect of M on DV	Direct effect	Indirect effect	Total effect
		b [95 % CI]	c' [95 % CI]	ab [boot95 % CI]	c [95 % CI]
GAD-7	OS	.114 [.042, .186]	-.005 [-.015, .005]	.044 [.011, .009]	-.001 [-.010, .009]
PHQ-9	OS	.115 [.044, .187]	-.006 [-.015, .004]	.004 [.001, .008]	-.002 [-.011, .008]

Note: 95% confidence intervals (CIs) shown in bold are significant; CIs for the indirect effect (boot95% CIs) were estimated based on 5000 bootstrap samples. Independent variable: Mentalizing tendency (absolute value of difference between ratings of neutral faces in the identity-maintained and identity changed conditions) for joy-to-neutral sequences. Mediator (*M*): Orienting Sensitivity Scale (OS). Dependent variable (DV): GAD-7 = General Anxiety Disorder-7, PHQ-9 = total score on the Patient Health Questionnaire-9.

Objective 4: Determining if Personality Captures Unique Variance in Anxiety and Depression Beyond That Accounted for by Emotion Anticipation

In addressing this objective, I ran multiple regressions predicting severity of anxiety and depressive symptoms. Predictors included ratings associated with joy-to-neutral and anger-to-neutral sequences (identity maintained) as well as total scores on the TAS-20, HSPS, and OS. Forced entry method was used and 95% confidence intervals were estimated based on 1000 bootstrap samples. Both models were significant [Anxiety: $R^2 = .467$, $F(5, 139) = 24.349$, $p < .001$; Depression: $R^2 = .311$, $F(5, 139) = 12.543$, $p < .001$]. When controlling for personality, perceptual ratings were not significant predictors of either outcome. However, TAS-20, HSPS, and OS scores each accounted for significant variance in the severity of symptoms of both anxiety and depression (see Table 3.3).

Table 3.3

Relationships Between Task Performance in the Identity-maintained Condition, Personality, and Mental Health

Outcome	Predictors	<i>B</i>	<i>SE</i>	95% CI Lower	95% CI Upper	<i>p</i>
GAD-7	(Constant)	-22.226	4.374	-30.434	-13.052	<.001
	Anger	0.068	0.936	-1.784	1.634	.945
	Joy	0.514	0.876	-1.146	2.326	.554
	TAS-20	0.197	0.033	0.131	0.264	<.001
	HSPS	1.157	0.528	0.124	2.176	.025
	OS	2.874	0.53	1.846	3.863	<.001
PHQ-9	(Constant)	-13.505	5.699	-23.765	-1.968	.020
	Anger	-0.008	1.099	-2.169	1.81	.995
	Joy	-0.255	1.107	-2.483	1.946	.814
	TAS-20	0.21	0.037	0.134	0.288	<.001
	HSPS	1.524	0.654	0.181	2.83	.022
	OS	1.458	0.597	0.308	2.489	.018

Note: Predictors included: ratings of neutral faces in the identity-maintained condition for anger-to-neutral sequences (Ang) and joy-to-neutral sequences (Joy); and scores on the Toronto Alexithymia Scale (TAS-20), Highly Sensitive Person Scale (HSPS), and Orienting Sensitivity subscale (OS). 95% confidence intervals (CIs) estimated using 1000 bootstrap samples. Bolded coefficients are significant.

Discussion

The present study had four main objectives: 1) to replicate the EA effect and see if it varies as a function of participant sex or perceptual history; 2) to determine if SPS and/or alexithymia are directly or indirectly related to the size of OBs seen in the identity-maintained condition; 3) to determine if those reporting significant anxiety or depression exhibit a “negativity bias” in task performance; and 4) to determine if personality captures unique variance in anxiety and depression, beyond that accounted for by EA effects.

Regarding objective 1, I was able to replicate the EA effect, as outlined by Palumbo and Jellema (2013). Specifically, in line with my hypothesis, neutral faces appearing at the end of joy-to-neutral sequences were rated as slightly angry, while neutral faces appearing at the end of anger-to-neutral sequences were rated as slightly joyful; however, these effects disappeared

when an identity change was introduced. The fact that the mentalizing index fully mediated the link between OS and OBs seen in the identity-maintained condition provides further strength to Palumbo and Jellema's (2013) argument that the OB is related to a mentalizing process; that is, that individuals are attempting to anticipate what another person is feeling, and preparing for a shift in their mood (whether to a more positive, joyful mood or a more negative, angry mood). Overall, OBs did not vary as a function of participant sex and were only slightly larger for joy-to-neutral than anger-to-neutral sequences in the identity-maintained condition. However, participants appeared to be more likely to mentalize when processing joy-to-neutral sequences as evidenced by showing a larger reduction in the size of OBs for these sequences when an identity change was introduced in the final frame.

Regarding objective 2, my finding that high scores on the TAS-20 were not related to the size of OBs seen in the identity-maintained condition was somewhat surprising. However, it is possible that an indirect relationship between specific facets of alexithymia and OBs might exist. For example, it may be that EOT is indirectly related to the size of the OB, as it has been shown elsewhere that EOT has been indirectly linked to interoceptive and mentalizing deficits (Jakobson et al., 2024; Jakobson & Rigby, 2021). As a result, taking a facet-level approach will be important in future work.

As expected, I did find that SPS traits captured by the OS scale were better predictors of EA for joy-to-neutral sequences than SPS traits captured by the HSPS. This makes sense as items in the OS scale tap into awareness of how subtle environmental cues affect one at an emotional level, and into processes not driven by sensory stimuli that could support deep processing of information (e.g., problem solving, experiencing frequent imagery).

The fact that the OS predicted OBs for joy-to-neutral but not anger-to-neutral sequences suggests that individuals scoring high, compared to low, on the OS are especially sensitive to possible incoming threats (e.g., another's mood shifting toward anger), as opposed to more positive signals (e.g., another's mood shifting toward joy). These same individuals, then, might also behave in a more cautious manner; indeed, those scoring high on SPS do tend to “pause to check” before responding (Aron et al., 2012). Responding in that way might be adaptive as it would help to keep those individuals safe. Taken to an extreme, however, these individuals may believe that the safest response is to isolate themselves, which may contribute to challenges with interpersonal relationships and the development or worsening of social anxiety. For example, Wolters et al. (2023) found that social isolation, depression, social anxiety, general anxiety, and loneliness were all inter-related. They also discussed how social isolation can further impact an individual's ability to experience social loneliness (i.e., lack of social ties), and emotional loneliness (i.e., lack of emotional connections). This would then lead to a plethora of challenges and barriers for those more sensitive individuals.

My hypothesis that mentalizing would be a stronger mediator of the link between personality and OBs than vividness of imagery was supported in the case of joy-to-neutral sequences. I found that the OS predicted the “mentalizing” index, demonstrating that the higher one's scores on the OS, the more likely it was that the individual would be affected by an identity change. This complements findings from Jakobson et al. (2024), who found that “positive” SPS traits (including OS) were related to the tendency to mentally project oneself into fictional scenarios and empathize with the characters. The same mentalizing processes may help one anticipate upcoming shifts in others' mood. This finding provides further strength to Palumbo and Jellema's (2013) argument that OB is related to a mentalizing process; but the fact

that the mentalizing index in the present study was larger for joy-to-neutral than anger-to-neutral sequences suggests that this process is most strongly engaged for threat assessment. Wu et al. (2020) suggest that a key component of mentalizing is being able to guess how another individual might behave, even if one is incorrect about the behaviour. It makes sense for individuals to rely especially heavily on the ability to anticipate when another individual might be becoming angry, as it would help them to prepare for a possible negative interaction. Future research should explore other factors that might influence mentalizing (particularly about threats), such as attachment style in childhood (e.g., Luyten et al., 2020).

As expected, the OS positively predicted self-reported vividness of imagery. Although imagery vividness did not mediate the relationship between OS and the size of the overshoot seen with joy-to-neutral sequences in the present study, it would be interesting to determine if it might be a more important factor when processing other emotions, such as fear. Imbriano et al. (2020) demonstrated that when individuals are cued with a fear label, they are better able to detect blurry images of fearful and neutral faces, and that this effect is enhanced in those who score high on vividness of imagery. The authors suggested that, when drawing on prior knowledge to guide decision-making, people who experience vivid imagery may generate more vivid threat-related templates, and that this could exert a top-down influence on perception.

Regarding objective 3, my hypothesis that those with anxiety or depression would show larger OBs for fading joy sequences and smaller OBs for fading anger sequences than non-anxious or non-depressed individuals was not supported. In fact, the groups performed similarly regardless of perceptual history. However, I was able to demonstrate that the tendency to anticipate a negative shift in another's affective state is linked to mental health problems in individuals who score high (vs. low) on orienting sensitivity. Worsening mental health symptoms

might result in these individuals more closely monitoring cues that might signal this shift. Indeed, links between anxiety and depression and heightened sensitivity to threat-related information has been described elsewhere (Vos et al., 2025). Measuring RTs in a future study might provide additional insights, given that Suslow et al. (2001) reported that depressed individuals may show similar performance in recognition of facial expressions to non-depressed individuals, but that their responses might be slower when detecting positive facial expressions.

The present results complement findings linking anxiety and depression to other cognitive/attentional biases, such as catastrophizing (e.g., Garnefski & Kraaij, 2006; Gautreau et al., 2015). Future studies could explore whether orienting sensitivity is also associated with these biases. Others have made an argument for examining gaze-by-expression interactions in samples that include those with mood and anxiety disorders (Fox et al., 2007; Li et al., 2017; Schulze et al., 2013). In this regard, an interesting extension of the present work might be to manipulate gaze direction. For example, one might explore whether OBs vary in socially anxious individuals as a function of whether a joy-to-neutral sequence does or does not incorporate a switch from averted to direct gaze, or vice versa. As OS is strongly correlated with social-affective sensitivity and other “positive” features of SPS (see De Gucht et al., 2022), it seems likely that it might play a role in mediating effects related to these manipulations.

Regarding objective 4, my hypothesis was supported. I found that OBs did not predict anxiety and depression when variance related to TAS-20, HSPS and OS scores was held constant. This suggests that other factors related to these personality traits (e.g., poor emotional regulation resulting from maladaptive coping; Eşkisu et al. 2022; Preece et al., 2023) are playing a bigger role in mental health outcomes than EA effects, themselves. Indeed, Tran and Lumley (2019) suggest that for university students, maladaptive coping in tandem with other factors,

such as experiencing negative mental health stigma, contributes to worsening psychological distress and increased depressive symptoms.

Strengths and Limitations

The present study had many strengths, including the use of a behavioural task of emotion anticipation and psychometrically robust self-report measures. Furthermore, findings related to OS underscored the importance of including this variable in research studies that investigate links between SPS and affective processing. Despite these strengths, this study also included limitations; but it also suggests paths for future researchers to explore.

First, although my sample size was judged to be adequate when testing the mediation models described here, it would be important to try to replicate these findings in a larger sample. Obtaining a larger sample would be particularly important if one wanted to test more complex models (Sim et al., 2022). Moreover, longitudinal research would strengthen any conclusions that are drawn, as it would allow for the assessment of causal effects.

Work in our lab has suggested that individuals scoring higher in SPS are more empathic (McQuarrie et al., 2023), which may mean that those same individuals would show a larger OB for facial expressions that indicate a shift toward feelings of distress (e.g., fear or sadness). However, neither of the perceptual histories used in this study included stimuli displaying these types of emotions. This is unfortunate as fear and sadness may relate more closely to anxiety and depression (respectively) than the emotions that were studied here. However, Palumbo and Jellema (2013) noted that, at their apex, the facial expressions of joy and anger are more comparable to one another than joy is to either sadness or fear. They also argued that the degree of geometrical change in the face when moving from apex to neutral is more similar for joy and anger than for joy and either sadness or fear. As a result, they suggested that it would be

problematic to compare OBs for either sad-to-neutral or fear-to-neutral sequences to those seen with joy-to-neutral sequences.

Lastly, a limitation of this study was that the data were collected online and, as such, the testing conditions were variable. Despite Peyton et al. (2022) suggesting that online testing does not create issues with the generalizability of findings, future researchers may wish to try to replicate these results using in-person testing.

Conclusions

The present study provides further support for the idea of an EA effect; that is, that OBs in ratings of neutral faces appearing at the end of sequences showing a fading expression reflect the operation of a mentalizing process. If this were not the case, then changing the identity of the face in the final frame would not disrupt the effect. The fact that the OS was indirectly linked to the size of the OB for joy-to-neutral sequences via mentalizing lends further preliminary support to the idea that an individual's sensitivity to subtle cues and ability to mentalize play an important role in the predictive mechanisms involved in threat assessment.

My findings also lend support to the idea that, among individuals reporting strong orienting sensitivity, anxiety and depression may be related to a negativity bias, as reflected in a larger OB for joy-to-neutral sequences. Being able to anticipate a shift in another's mood toward anger can be adaptive, as it can help keep one safe. However, overinterpreting these cues may negatively impact social functioning. Tailoring therapeutic interventions that focus on body sensations and cognitive flexibility (e.g., "are they mad at me or are they mad at a situation that they are describing to me?") could be especially important for individuals who show this strong tendency. These approaches, which are aimed at improving mental health symptoms, can also

result in lower scores on both SPS (e.g., Holm et al., 2019) and alexithymia (e.g., Sagar et al., 2021). Additional clinical implications are discussed in Chapter 5.

CHAPTER 4: FUTURE THINKING

Previous work discussed in this document suggests several ways that individuals might utilize mental imagery/simulation in the moment. In this chapter, I turn to the question of how individuals imagine future situations that have not yet occurred. What factors underlie individual differences in this ability, and how does FT relate to mental health?

In recent years, FT has received ample attention in the literature. This term refers to the ability to simulate oneself in the future and to visualize and mentally experience potential future situations (Atance & O'Neill, 2001; Du et al., 2022; Szpunar, 2010; Szpunar et al., 2014). Several models have been presented to account for FT. For example, Tulving (1983, 1985) discusses the importance of consciousness and the use of episodic memory for supporting *mental time travel*. In this account, one draws on memories from the past to create simulations of events that might occur in the future. However, some researchers posit that the ability to engage in mental time travel is not solely reliant on episodic memory. Indeed, Addis and Szpunar (2024) propose a novel, more fluid, multidimensional framework of conceptualizing thoughts and imagining the future. Their *multidimensional model of mental representations* involves individual representations that can be distinguished by their placement along three continuous dimensions: (a) temporal specificity, which runs from general (e.g., an individual's elementary school) to specific (e.g., an individual's 6th grade graduation); (b) content type, which runs from conceptual (e.g., politics is important) to perceptual (e.g., the smell of your mother's perfume); and (c) self-reference, which runs from shared (e.g., the hope that all cancers will have a cure) to idiosyncratic (e.g., an individual's goal to get their driving license).

Projecting oneself into the future is not a static process. Schacter et al. (2008) describe the importance of hypothesizing multiple possible outcomes during FT in order to best prepare

for various situations. An important factor that may influence preparation is one's assessment of the likelihood that a given outcome will occur. Research suggests that we apply certain heuristics when arriving at these estimates. Tversky and Kahneman (1973) proposed that estimates of the likelihood of future events occurring are influenced by how easy it is to draw on examples from memory (the *availability heuristic*). Several years later, Kahneman and Tversky (1982) built on their earlier model and noted that, for unique or unlikely events, the ease of constructing the scenario impacted estimates of how likely individuals thought it would be to occur (the *simulation heuristic*). These kinds of heuristics can bias an individual's predictions about what will happen in the future, which could impact decision making for better or worse.

Schacter et al. (2008) argue that "simulation of future events involves more than simple imagery. [It is] a particular kind or subset of thinking that involves imaginatively placing oneself in a hypothetical scenario and exploring possible outcomes" (p. 42). Nonetheless, Conti and Irish (2021) highlight that visual imagery plays an important role in FT and in the richness of simulated/imagined representations. In a series of experiments, Lee et al. (2017) demonstrated that participants are better able to imagine scenarios in the near future in vivid colour, while they are more likely to imagine distant scenarios in black and white. Complementary findings come from research into consumer behaviour. For example, in a study exploring shoppers' willingness to purchase a revamped product that is familiar vs. one that is brand-new, Zhao et al. (2014) found that providing concrete information about a product was beneficial when asking individuals to visualize past experiences but that providing more abstract information allowed for better activation of imagery for products to be encountered in the future. Together, the findings from these studies suggest that the quality of imagery supporting FT may shift as the time frame

changes, becoming less vivid/detailed (or more abstract) the further into the future one projects oneself.

In research exploring how individuals engage in intentional imagining about positive and negative events that might take place in the future, Hallford et al. (2020b) found a moderate correlation ($r = .38$) between participants' ratings of how vivid/detailed the images they formed were and scores on a measure assessing their spontaneous use of imagery. This supports the idea that qualities of the future-oriented images one is able to intentionally generate, or other aspects of FT related to this (such as estimates of the likelihood of certain events occurring), may vary as a function of individual differences in the tendency to engage in daydreaming or fantasizing—imaginative activities that involve episodic memory retrieval, visualization, mental simulation, spatial navigation, and FT (Jung et al., 2016). Identifying factors that may contribute to these individual differences is important for theoretical and scholarly reasons, but this work may also have significant clinical implications. In service of this goal, my focus was on examining links between specific aspects of FT and the two personality variables discussed in the previous chapters. In the following section, I discuss some of the existing work in this area.

Individual Differences in FT: Links to Alexithymia and SPS

Past work suggests that alexithymia is associated with a reduced capacity for imagery (Peasley-Miklus et al., 2016) and an impoverished fantasy life (Sifneos, 1973). In an fMRI study conducted by Mantani et al. (2005), participants were told to imagine happy, sad, and emotionally neutral situations regarding both a past and a possible future event. It was found that those with high degrees of alexithymia rated the past and future sad events as less vivid and arousing than those with low degrees of alexithymia. It is possible that this reflects a top-down effect related to the use of coping strategies such as emotional suppression. Indeed, individuals

suffering from post-traumatic stress disorder tend to score high on both alexithymia and emotional suppression (Chung & Hunt, 2014).

Participants in the Mantani et al. (2005) study also showed reduced activation in the posterior cingulate cortex when imagining past and future happy events relative to activity seen at rest, and when imagining future happy events relative to when imagining future negative events. Given the role this brain area is thought to play in episodic memory, the authors suggested that individuals with alexithymia may not draw on long-term memory when constructing or evaluating the emotional significance of future happy events. This may relate to the fact that others have reported reduced optimism (e.g., Stepura et al., 2024) and a heightened tendency to anticipate negative events (Starita et al., 2016) in those scoring high on this trait. Indeed, alexithymia is related to catastrophizing, which involves focusing on the worst possible outcome of a situation and treating it as highly likely to occur even when there is little evidence to support that prediction (Lumley et al., 2002).

Unlike alexithymia, SPS is linked to having a rich inner life and frequent fantasizing (Aron et al., 2012). There is limited research investigating the relationship between SPS and qualities of cued imagery of possible positive and/or negative future events. However, people scoring high on this trait do report frequent, vivid dreams (a form of uncued or spontaneous imagery; Schredl et al., 2020, 2022) that can be intensely positive or negative in valence (Carr & Nielsen, 2017). In addition, like alexithymia, SPS has been found to be related to catastrophizing (Yano & Oishi, 2024). Meyer and Carver (2000) reported that highly sensitive individuals who have experienced adverse childhood experiences (i.e., rejection, isolation) often assume that bad things might happen to them and try to avoid situations that might have negative outcomes (features linked to avoidant personality disorder).

Links Between FT and Mental Health

The preceding discussion suggests that aspects of FT, which may be shaped by alexithymia and/or SPS, can negatively impact how we see our lives unfolding in the future. There is also a growing literature examining links between FT, emotion regulation, and mental health. Schubert et al. (2020) conducted a meta-analysis that examined links between FT and both positive and negative affect outcomes. Results suggested that imagining the future had a bigger impact on affect than remembering the past, but that its effects may or may not be helpful. On the positive side, they cited work showing that future thinking can support and encourage effective coping and emotion regulation. For example, being asked to imagine one's "best possible self" or to simulate a future scenario that resolves positively can increase positive affect and decrease worry related to the event (Brown et al., 2002). In contrast, being prompted to worry about a future event (especially one that results in a long-term negative outcome for an individual) was shown to increase negative affect. Schubert et al. (2020) concluded that worry is a key maladaptive cognitive strategy. These authors also discussed possible moderators between FT and affect. For example, they noted that reducing the temporal distance of an imagined event increases its impact on affect. An additional moderator appeared to be how vividly individuals can imagine a future event, with individuals who imagine positive situations more vividly experiencing more happiness than those who imagine these situations less vividly.

Researchers have also turned their attention to optimism as a variable impacting simulation and FT. Thinking about the future can increase positive affect if individuals *believe* that good things will happen to them. For example, Sharot et al. (2007) demonstrated that healthy individuals scoring high on an optimism scale were especially likely to rate positive events that might occur in the future more positively than positive events that occurred in the past. Optimists

also found that possible positive future events felt closer in time than possible negative future events. These findings demonstrate the protective factor that optimism may play in FT and mental health.

In contrast to the benefits of optimistic views of the future, pessimistic views may pose a risk to an individual's mental health. Research has suggested that individuals with depression, as opposed to anxiety, are more pessimistic about the future, and find it more challenging to generate positive future scenarios (MacLeod et al., 1997). Depression severity is also correlated with how readily an individual can construct a negative future event and how strongly one believes that a negative event is likely to occur in the future (MacLeod & Cropley, 1995). This relates back to the simulation heuristic, whereby how easily an individual constructs a future situation is related to how likely they believe it is to occur.

Depressed individuals also engage differently in FT than those who are not depressed. For example, depressed individuals may experience less specificity, or broader, FT (Gamble et al., 2019; Hallford et al., 2018; Sumner et al., 2010); for example, they may think about all the times that they failed at an activity, instead of thinking about a time where they met a goal. Perhaps as a result of reduced specificity, depressed individuals also experience reduced pleasure when imagining possible positive future events (Hallford et al., 2020a). Other work suggests that, although people with dysphoria (i.e., probable major depression) experience just as many instances of FT related to goal setting as those who are not dysphoric (Dickson et al., 2011), they maladaptively conclude that negative events are more likely to come to fruition than positive events (Beck et al. 2006).

Roepke and Seligman (2016) suggest that the tendency for depressed individuals to engage in negative FT is a core causal element of the disorder. They propose that depressed

individuals have difficulty in simulating positive futures and evaluating the probability of positive futures, and that they hold negative beliefs about the future. Moreover, their model posits that each element interacts with the other, creating a negative FT cycle that further maintains and worsens symptoms of depression. Although Cognitive Behavioural Therapy (CBT) has shown some evidence of improving future-thinking (e.g., Anderson et al., 2013), Roepke and Seligman (2016) offer other directions (e.g., future-directed therapy, solution-focused therapy) to assist depressed individuals in becoming more optimistic that positive events will occur in the future.

Research has also explored the association between anxiety and FT. Du et al. (2022) completed a meta-analysis to examine this link. They noted a positive correlation between anxiety and an individual's ability to generate a vivid and detailed simulation of the future when negatively cued (e.g., by a word, by an event). However, they also described work suggesting that, if an anxious individual is able to tolerate thinking about potential negative situations in the future, simulation allows them to rehearse and practice potential responses to be better prepared should those situations occur (Taylor & Schneider, 1989). This is, in part, why exposure therapy has been considered the gold standard in treatment of anxiety disorders (e.g., see meta-analysis by Norton & Price, 2007).

Du et al.'s (2022) meta-analysis also addressed the extent to which the research they reviewed provided support for each of three core theories about anxiety: Cognitive Avoidance Theory, Attentional Control Theory, and Contrast Avoidance Theory. According to Cognitive Avoidance Theory (Sibrava & Borkovec, 2006), anxious individuals use cognitive avoidance to deal with uncomfortable or distressing feelings, thoughts, or images. This leads to a general reduction in the vividness or specificity of their FT. According to Attentional Control Theory

(Derakhshan, 2020), anxious individuals have difficulty inhibiting attention to negative cues in their environment. Finally, proponents of Contrast Avoidance Theory suggest that anxious individuals would rather remain in a negative affective state than try to manage sudden and strong negative reactions to stimuli (Newman & Llera, 2011). The focus on negative cues that is a feature of the latter two theories is thought to trigger more vivid and specific negative (vs. positive) FT. From their review, Du et al. (2022) found more support for these latter two theories than for Cognitive Avoidance Theory.

Researchers have explored the impact of intrusive imagery and thoughts about the future on mental health. These are typically unwanted and persistent, and cause distress and anxiety for those experiencing them (Clark & Rhyno, 2005). Depressed individuals not only experience vivid intrusive images of past negative events but also of possible future negative events (Patel et al., 2007), such as those related to death and dying by suicide (Gregory et al., 2010). Anxious individuals also experience intrusive images and thoughts. For example, individuals with health anxiety may be bothered by images and thoughts of becoming ill, and what the course of the potential future illness may involve (Windsor et al., 2024), leading them to engage in maladaptive coping strategies such as avoidance, reassurance seeking, distraction, checking, or rumination (Muse et al., 2010). Intrusive imagery may arise entirely from one's imagination, rather than from reexperiencing a negative memory (Cili & Stopa, 2015). By inflating one's belief that a negative situation may occur, imagination might prompt the use of maladaptive coping strategies.

López-Pérez et al. (2018) conducted a FT study that explored the extent to which incarcerated individuals' ability to imagine possible positive or negative future events when cued, their propensity to experience intrusive images and thoughts, their ratings of the perceived

impact of future negative events, and their trait imagery vividness predicted current levels of depression and anxiety. Participants reported more intrusive visual imagery than verbal thoughts and reported that negative events that they imagined were more vivid and arousing than positive events that they imagined. In addition, depression was negatively predicted by the vividness and perceived likelihood of positive events occurring and positively predicted by the perceived negative impact of future events; and anxiety was negatively predicted by the likelihood of positive events occurring and positively predicted by intrusive verbal thoughts and the perceived impact of negative events occurring. This research demonstrates how variables such as the vividness and intrusiveness of FT, and the perceived likelihood of future events occurring, may influence mental health.

The Present Study

The first objective of the present study was to examine relationships between specific FT-related study variables in a sample of university students. I first set out to compare intentional (cued) imagery of positive and negative future events on the basis of participants' ratings of their vividness, the emotional arousal they evoke, and the likelihood that they might occur. I also sought to examine the relationship between experiencing intrusive (spontaneous) visual imagery and verbal thoughts. López-Pérez et al. (2018) found that incarcerated individuals reported that cued images regarding future negative events were more vivid and arousing than cued images of positive events, and that they experienced more intrusive images than intrusive thoughts. However, whether these effects would hold in a sample of undergraduates was unclear.

Based on the work of Hallford et al. (2020b), I predicted that people who are able to (intentionally) generate more vivid and arousing negative imagery would also experience more frequent intrusive spontaneous imagery. In addition, as experiencing frequent intrusive FT is

associated with distress and anxiety (Berntsen et al., 2015), which could exacerbate catastrophizing or rumination tendencies, I also predicted that Intrusive Visual Imagery (IVI) and Intrusive Verbal Thought (IVT) would account for unique variance in likelihood ratings for negative scenarios. Finally, I predicted that IVI, IVT, and likelihood ratings for negative scenarios would positively predict ratings of how big an impact future events would be likely to have after controlling for other aspects of FT.

My second objective was to examine whether specific facets of alexithymia and/or SPS contribute to individual differences in vividness and arousal associated with future-oriented imagery, the tendencies to experience intrusive thoughts and/or images, and/or ratings of the likelihood of future events and their perceived impact. Unlike most of the past work in this area, I took into consideration the fact that alexithymia and SPS are both multifaceted. As noted earlier, alexithymia is a trait characterized by difficulties identifying and describing one's feelings (Nemiah et al., 1976). Some individuals with alexithymia also report having an externally oriented thinking style and an impoverished fantasy life (Sifneos, 1973) particularly lacking in emotionally arousing imagery (Peasley-Miklus et al., 2016). The features of SPS fall into two clusters. "Negative" SPS (SPS-) traits include sensitivity to stimuli or situations that are unpleasant, whereas "positive" SPS (SPS+) traits include (among other things) sensitivity to subtle internal and external stimuli and having a rich "inner life" (De Gucht et al., 2022; Jakobson et al., 2024). Little is known about how these different facets of alexithymia and SPS relate to FT. In exploring this, one must account for the fact the facets of these traits are inter-related. Thus, DIF and DDF are associated with strong SPS- traits, and EOT is associated with weak SPS+ traits (Jakobson et al., 2024). A novel contribution of the research described in the present study is that I controlled for facets of SPS when assessing relationships between facets of

alexithymia and FT, and vice versa. This allowed me to assess the unique variance accounted for by each personality variable. Taking this facet-level approach may provide new insights into links between different aspects of FT and these traits.

Raghunath et al. (2021) found that highly reactive individuals had stronger mental imagery for negatively than positively valenced words. This may relate to the finding that SPS- traits include experiencing heightened emotional reactions to unpleasant stimulation (De Gucht et al., 2022). In contrast, SPS+ traits include heightened sensitivity to subtle stimuli (including those which are internally generated), regardless of valence (De Gucht et al., 2022). In addition, the research described in Chapter 3 demonstrated that higher scores on the OS, which falls in the SPS+ cluster, predicted greater self-reported imagery vividness when controlling for HSPS and TAS-20 scores. Given these results, I expected to find that higher SPS- scores would predict stronger emotional arousal for negative images, and that higher SPS+ scores would predict stronger ratings of arousal for positive images and for vividness of cued, future-oriented imagery regardless of valence. This would give rise to perceptually rich simulations of future events (see Ramanan et al., 2018).

Jakobson et al. (2024) found that both positive and negative features of SPS mediated the negative link between EOT and fantasizing tendencies. However, research into the Big Five has linked both DIF/DDF (Attary & Ghazizadeh, 2021) and SPS- traits (Lionetti et al., 2019) with neuroticism, which is associated with a tendency to recall negative memories and to simulate negative future events (Quoidbach et al., 2008). Based on these findings, I expected to find that DIF, DDF, and/or SPS- traits would be stronger positive predictors than EOT and/or SPS+ traits of intrusive FT, ratings of the likelihood of negative events occurring, and ratings of the impact

of future events. However, I expected that scoring low on EOT and/or high on SPS+ traits might still account for some of the variance in these measures.

My final objective was to use hierarchical regressions to explore links between aspects of FT that may be related to SPS and/or alexithymia and self-reported levels of anxiety and depression; this might offer new insights into why these personality traits are considered strong risk factors for these common mental disorders. Regarding depression, research discussed in this chapter has demonstrated that depressed individuals experience more vivid and arousing negative than positive imagery (López-Pérez et al., 2018). On these grounds, I expected to find that high emotional arousal and vividness of negative scenarios (and/or low emotional arousal and vividness of positive scenarios; Pearson et al., 2015) would significantly predict depression severity. As experiencing frequent intrusive FT is associated with heightened distress (Berntsen et al., 2015), I expected to find that experiencing frequent spontaneous intrusive thoughts and imagery would improve prediction of depression severity. I also predicted that, as depressed individuals demonstrate a default cognitive style of being pessimistic toward the future (MacLeod et al., 1997), ratings of how likely negative events were to occur would further improve prediction of depression scores (MacLeod & Cropley, 1995). Finally, I predicted that adding ratings of the perceived impact of future events would also improve the model.

Regarding anxiety, Du et al. (2022) suggested that anxious individuals may experience more vivid and negative FT, while López-Pérez et al. (2018) found that anxiety was positively predicted by intrusive verbal thoughts and the perceived impact of negative events occurring and negatively predicted by the perceived likelihood of positive events occurring. For these reasons, I expected to find that the vividness of and emotional arousal evoked by imagining negative scenarios would significantly predict anxiety ratings, and that adding information about the

frequency of intrusive verbal thoughts, the perceived likelihood of events occurring, and the perceived impact of future events would each significantly improve the model.

Method

Participants

After exclusions (see Data Cleaning below), this study included a convenience sample of 167 undergraduate students recruited from an Introduction to Psychology subject pool at the University of Manitoba (82 female, 85 male; $M_{\text{age}} = 22.6$, $SD = 6.1$). Participants provided informed consent and were compensated for their time with credit towards a research participation option in their Introduction to Psychology course.

General Procedure

The data obtained for the present study were collected online using the Qualtrics Survey Platform (RRID: *SCR_016728*). After informed consent was obtained, participants completed a demographic questionnaire, the PHQ-9, the GAD-7, the TAS-20, the HSPS, and the OS, which were described in previous chapters (see pp. 22-23, and 46). The subscales of the HSPS include: (a) Low Sensory Threshold (LST) that involves being over-sensitive to strong stimuli that make one feel uncomfortable; (b) Ease of Excitation (EOE) that involves becoming easily overwhelmed; and (c) Aesthetic Sensitivity (AES) that involves being attuned to one's emotional reactions to aesthetic cues (e.g., a room's lighting, music, the visual arts). The subscales of the OS were described earlier (see pp. 46). The SPS- trait cluster includes LST and EOE, while the SPS+ trait cluster includes AES, AS, NPS, and APS (Jakobson et al., 2024).

In addition to the measures noted above, participants completed several measures unique to the current study, which are described below. These included the Impact of Future Events Scale (IFES), the Intrusive Visual Imagery (IVI) and Intrusive Verbal Thought (IVT)

questionnaires, the Prospective Imagery Test (PIT), a validity check, and one additional measure unrelated to the present study. The testing protocol was approved by the Research Ethics Board at the University of Manitoba, Fort Garry Campus.

Measures Unique to the Current Study

The Impact of Future Events Scale

The Impact of Future Events Scale (IFES; Deeptose & Holmes, 2010) asks participants to recall three future events that they have been thinking about over the past seven days. The events can either be positive, negative, or a mix of both. Once the participant has indicated what the events are, they are then asked to respond to 24-items that relate to possible comments that may be true for them about the events. Each item is responded to on a 5-point Likert scale, ranging from 0 = *Not at all* to 4 = *Extremely*. Higher scores indicate stronger beliefs that the possible future events will have a large impact. An example item is “I believed my thoughts about the future would definitely happen and would become real; I thought about the future when I didn’t mean to.” In the present sample the IFES showed good internal consistency (IFES $\alpha = .89$).

Intrusive Visual Imagery and Verbal Thought Questionnaires

The Intrusive Visual Imagery (IVI) and Intrusive Verbal Thought (IVT) questionnaires (McCarthy-Jones et al., 2012) are two, 10-item self-report measures that assess the degree to which an individual experiences intrusive imagery or verbal thoughts, with higher scores indicating higher levels of these tendencies. An example item for the IVI would be “I have images in my mind that I cannot stop” while an example item for the IVT would be “I have verbal thoughts in my mind that I cannot stop.” Participants are asked to indicate the degree to which each statement applies to them using a 5-point Likert scale ranging from 1 = *Strongly disagree* to 5 = *Strongly agree*. Responses are then summed to yield a total score ranging from

10 to 50 for each scale. In the present sample the scales showed high internal consistency (IVI $\alpha = .90$; IVT $\alpha = .93$).

Prospective Imagery Test

The Prospective Imagery Test (PIT; Stöber, 2000) is a 30-item self-report that measures how vividly participants can imagine 10 positive future events, and 20 negative future events. To balance the set, I selected 10 negative and 10 positive items that were complementary. For example, one set of complementary items included “*You will be very fit and healthy*” (positive scenario) and “*You will have health problems*” (negative scenario) (see Appendix for the full set used in the present study). A similar modification has been made in previous research (e.g., Morina et al., 2011). After each hypothetical event is read, participants will be asked to rate on a 5-point Likert scale how *vivid each image is* (1 = *no image at all* to 5 = *very vivid*), how *emotionally aroused they feel when imagining the event* (1 = *no emotional response* to 5 = *strong emotional response*), and how *likely it is that the event might occur in the future* (1 = *not at all likely to occur* to 5 = *extremely likely to occur*). Mean ratings on each dimension are computed for positive and negative items, to produce subscores having a possible range of 1 to 5. In the present sample, the scales of the PIT had acceptable to good internal consistency for positive items (measurement of vividness; $\alpha = .87$; measurement of arousal; $\alpha = .85$; measurement of likelihood; $\alpha = .76$) and good internal consistency for negative items (measurement of vividness; $\alpha = .89$; measurement of arousal; $\alpha = .88$; measurement of likelihood; $\alpha = .86$).

Results

Data Cleaning and Statistical Analysis

The initial sample included 192 respondents. Participants were removed from analyses if they did not complete questionnaires, if they failed a validity check asking if they had completed

the study in an attentive and serious manner, or if they made more than two errors on the Conscientious Responders Scale. In total, 25 participants were removed for one or more of the reasons noted above, leaving a final sample of 167. This provided adequate power ($> .80$) for all planned regression analyses, assuming an alpha of .05 and a medium effect size (G*Power 3.1.9.7). The significance of regression coefficients was assessed by examination of 95% confidence intervals estimated from 1000 bias-corrected and accelerated bootstrap samples.

Missing responses to any questionnaire items in the final sample were found to be missing completely at random and were estimated using an expectation maximization procedure before subscale or total scores were calculated. All statistical analyses were run in IBM SPSS Statistics (RRID: *SCR_016479*), version 29.

Objective 1: Examining Relationships Between Aspects of FT

To get a general overview of relationships between my study variables, I examined the descriptive statistics for and the zero-order correlations between them (see Table 4.1). As expected, the personality variables were positively correlated with one another and (with the exception of EOT) with both mental health variables, with small-to-large effect sizes. Interestingly, anxiety and depression were also both positively related to ratings of the vividness, emotional arousal, and likelihood of negative scenarios occurring, and depression was negatively related to the likelihood of positive scenarios occurring. Both mental health outcomes were also positively related to IVI/IVT and to estimates of the likely impact of future events.

The data presented in Table 4.1 also supported the views that: (a) reporting more vivid and arousing imagery for future negative (but not positive) events was associated with reporting more intrusive images and thoughts; (b) reporting experiencing more intrusive images and

Table 4.1*Descriptive Statistics for and Correlations Between Self-Report Measures*

	<i>M</i>	<i>SD</i>	PHQ9	GAD7	Vpos	Vneg	EApas	EAneg	Lpos	Lneg	IVI	IVT	IFES	EOT	DIF	DDF	SPS+
PHQ9	9.2	5.9	-														
GAD7	6.9	4.6	.717	-													
Vpos	3.7	0.8	-.039	.010	-												
Vneg	3.3	0.9	.380	.356	.313	-											
EApas	3.5	0.8	.108	.121	.615	.130	-										
EAneg	3.2	0.9	.383	.388	.117	.734	.382	-									
Lpos	3.7	0.6	-.169	-.110	.702	.039	.511	.003	-								
Lneg	2.9	0.8	.503	.425	-.098	.653	.013	.643	-.203	-							
IVI	32.8	9.0	.474	.532	.142	.479	.157	.451	-.072	.471	-						
IVT	30.8	9.6	.507	.558	-.010	.365	.103	.379	-.103	.486	.676	-					
IFES	44.3	16.3	.508	.553	.119	.223	.234	.236	.001	.293	.562	.572	-				
EOT	19.9	4.2	-.038	-.043	-.104	-.122	-.099	-.157	-.028	-.082	-.106	-.065	.083	-			
DIF	18.8	6.6	.583	.600	-.095	.329	-.008	.334	-.172	.460	.499	.574	.505	.009	-		
DDF	15.5	4.7	.450	.494	-.065	.335	-.019	.300	-.178	.424	.446	.434	.365	-.002	.735	-	
SPS+	4.8	0.8	.289	.367	.265	.281	.200	.212	.173	.215	.407	.355	.359	-.318	.269	.212	-
SPS-	4.2	1.1	.481	.430	.214	.196	.300	.248	.137	.199	.340	.319	.429	-.004	.410	.272	.520

Note: Patient Health Questionnaire-9 (PHQ9), General Anxiety Disorder-7 (GAD7), Vividness of Positive Imagery (Vpos), Vividness of Negative Imagery (Vneg), Emotional Arousal of Positive Imagery (EApas), Emotional Arousal of Negative Imagery (EAneg), Likelihood of Positive Scenarios (Lpos), Likelihood of Negative Scenarios (Lneg), Intrusive Visual Imagery (IVI), Intrusive Verbal Thought (IVT), The Impact of Future Events (IFES), Externally Oriented Thinking (EOT), Difficulty Identifying Feelings (DIF), Difficulty Describing Feelings (DDF), Sensory Processing Sensitivity Positive Cluster (SPS+), and Sensory Processing Sensitivity Negative Cluster (SPS-). Significant correlations ($p < .05$) are color coded according to effect size.

Large	Medium	Small	Small	Medium	Large
Negative correlations			Positive correlations		

thoughts was related to giving higher likelihood ratings for negative (but not positive) scenarios; and (c) intrusive thoughts, intrusive images, and the perceived likelihood of negative (but not positive) events occurring were all related to the tendency to anticipate that future events would have a large impact.

To address my study hypotheses, I first ran a series of paired samples *t*-tests to compare positive vs. negative PIT scenarios with regard to their vividness, emotional arousal, and likelihood ratings. Participants rated positive imagery as more vivid [$t(166) = 5.934, p < .001, d = .46$], as more emotionally arousing [$t(166) = 4.745, p < .001, d = .37$], and as more likely to occur [$t(166) = 8.579, p < .001, d = .66$] than negative imagery. In addition, when asked to recall three future events that they had been thinking about over the past seven days during completion of the IFES, the majority of participants recalled more positive than negative scenarios (27.8% recalling no negative events, 41.4% one negative event, and 30.9% two or three negative events).

I also compared IVI with IVT ratings. Overall, participants reported experiencing intrusive visual imagery more than intrusive verbal thoughts [$t(166) = 3.423, p < .001, d = .27$]. Supporting the view that these scales were capturing negative future-oriented intrusions to some degree, scores on these scales were related to the number of negative future events that participants recalled in the IFES when reflecting on what they had been imagining/thinking about in the past week, $H(2) \geq 8.009, p \leq .017$. Jonckheere's test revealed a significant trend in the data: those who recalled more negative future events also reported an increased tendency to experience more intrusive images ($J = 5183, z = 2.712, p = .007, r = .213$) and thoughts ($J = 5231, z = 2.860, p = .004, r = .225$).

To test my remaining hypotheses about how specific aspects of FT might relate to one another I ran five separate regression analyses. The results are presented in Table 4.2. In the first

Table 4.2
Relationships Future Thinking Variables

DV	IVs	<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>F</i>	<i>p</i>	Adjusted <i>R</i> ²
					LL	UL			
IVI	(Constant)	14.596	4.010	<.001	7.124	23.802	13.653	<.001	.234
	EApos	.768	1.411	.571	-2.109	3.481			
	EAneg	1.650	1.385	.238	-1.231	4.272			
	Vpos	-.346	1.438	.797	-3.009	2.259			
	Vneg	3.484	1.291	.005	1.034	6.111			
IVT	(Constant)	19.602	4.049	<.001	11.826	28.427	8.939	<.001	.161
	EApos	2.203	1.549	.144	-1.179	5.263			
	EAneg	.760	1.413	.588	-1.965	3.770			
	Vpos	-3.034	1.492	.041	-5.709	-.342			
	Vneg	3.764	1.385	.010	.668	6.264			
Lpos	(Constant)	1.728	.332	<.001	1.066	2.404	32.954	<.001	.536
	EApos	.046	.082	.558	-.105	.214			
	EAneg	.079	.072	.279	-.084	.227			
	Vpos	.618	.087	<.001	.443	.793			
	Vneg	-.154	.071	.038	-.306	-.005			
	IVI	-.011	.005	.028	-.021	-.002			
	IVT	.003	.005	.542	-.006	.013			
Lneg	(Constant)	1.338	.293	<.001	.805	2.033	40.596	<.001	.589
	EApos	.028	.105	.770	-.192	.236			
	EAneg	.190	.096	.054	-.00006	.400			
	Vpos	-.333	.103	.003	-.516	-.149			
	Vneg	.451	.084	<.001	.301	.591			
	IVI	.005	.007	.491	-.009	.018			
	IVT	.016	.006	.017	.003	.027			
IFES	(Constant)	-1.170	8.785	.880	-20.026	12.319	14.427	<.001	.393
	EApos	5.356	2.617	.047	.335	10.568			
	EAneg	-3.334	2.218	.134	-7.294	.396			
	Vpos	-.605	2.540	.822	-6.465	4.232			
	Vneg	.058	2.363	.982	-4.268	4.291			
	IVI	.607	.161	.002	.246	.934			
	IVT	.597	.158	<.001	.285	.923			
	Lpos	-.826	2.535	.753	-5.951	4.676			
	Lneg	1.382	1.883	.461	-2.386	5.857			

Note: Emotional Arousal of Positive Scenarios (EApos), Emotional Arousal of Negative Scenarios (EAneg), Vividness of Positive Scenarios (Vpos), Vividness of Negative Scenarios (Vneg), Intrusive Visual Imagery (IVI), Intrusive Verbal Thought (IVT), Likelihood of Positive Scenarios (Lpos), Likelihood of Negative Scenarios (Lneg), The Impact of Future Events (IFES). 95% confidence intervals (95% CIs) were based on 1000 bias-corrected and accelerated bootstrap samples (LL = lower limit, UL = upper limit).

set of regressions, vividness of negative imagery predicted higher scores on the IVI. I also found that, whereas the vividness of positive imagery predicted lower IVT, the vividness of negative imagery predicted higher IVT scores. Together, these findings are in line with my prediction that those who experience vivid negative imagery would also report more intrusive images and thoughts.

In the second set of regressions, I explored whether IVI and IVT accounted for additional variance in likelihood ratings, above and beyond the variables entered in the first set of regressions. Positive scenarios were rated as more likely to occur by those reporting more vivid positive imagery and as less likely to occur by those reporting more vivid negative imagery and IVI. Negative scenarios were rated as more likely to occur by those reporting more vivid negative imagery and IVT, and as less likely to occur by those reporting more vivid positive imagery. These findings are in line with my prediction that intrusive FT would account for variance in likelihood ratings.

In the final regression, I assessed the unique contribution made by likelihood ratings to predictions of the impact of future events. The emotional arousal elicited by positive imagery and both IVI and IVT positively predicted the IFES scores. Thus, my prediction that IVI, IVT, and the likelihood of negative events occurring would predict IFES scores after controlling for the remaining variables was partially supported.

Objective 2: Do Facets of Alexithymia and/or SPS Account for Unique Variance in FT?

To answer this question, I ran nine planned multiple regression analyses, where each of my FT-related measures was now treated as an outcome variable. The predictors included EOT, DIF, and DDF scores as well as SPS+ and SPS- composite scores. The results for all regressions are presented in Table 4.3.

Table 4.3*Relationships Between Personality Variables and Future Thinking*

DV	IVs	<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>F</i>	<i>p</i>	Adjusted <i>R</i> ²
					LL	UL			
EApos	(Constant)	2.980	.598	<.001	1.713	4.357	4.428	<.001	.094
	EOT	-.015	.015	.296	-.047	.013			
	DIF	-.017	.012	.140	-.040	.006			
	DDF	-.001	.018	.939	-.038	.034			
	SPS+	.036	.103	.739	-.154	.230			
	SPS-	.243	.058	<.001	.132	.368			
EAneg	(Constant)	2.386	.695	.002	.959	3.913	6.097	<.001	.159
	EOT	-.033	.017	.049	-.067	-.005			
	DIF	.026	.013	.050	-.003	.053			
	DDF	.024	.021	.261	-.018	.070			
	SPS+	.026	.128	.838	-.221	.253			
	SPS-	.109	.086	.198	-.049	.262			
Vpos	(Constant)	2.772	.617	<.001	1.529	3.906	4.592	<.001	.098
	EOT	-.006	.015	.711	-.035	.026			
	DIF	-.028	.014	.039	-.056	.000			
	DDF	.003	.020	.903	-.033	.040			
	SPS+	.213	.100	.033	.023	.421			
	SPS-	.139	.061	.027	.023	.246			
Vneg	(Constant)	1.570	.629	.015	.360	3.021	6.579	<.001	.144
	EOT	-.014	.016	.373	-.043	.013			
	DIF	.020	.014	.160	-.010	.050			
	DDF	.039	.021	.069	-.001	.079			
	SPS+	.231	.121	.061	-.010	.463			
	SPS-	-.012	.084	.875	-.172	.150			
IVI	(Constant)	4.651	5.341	.384	-6.019	14.961	16.761	<.001	.322
	EOT	-.050	.138	.712	-.299	.222			
	DIF	.396	.132	.007	.144	.639			
	DDF	.324	.188	.086	-.044	.666			
	SPS+	3.199	1.057	.003	1.264	5.268			
	SPS-	.308	.720	.665	-1.206	1.788			
IVT	(Constant)	3.424	5.940	.571	-6.960	14.635	19.210	<.001	.354
	EOT	-.001	.168	.998	-.333	.353			
	DIF	.729	.140	<.001	.457	.987			
	DDF	.038	.194	.844	-.327	.411			
	SPS+	2.776	1.094	.011	.533	4.840			
	SPS-	-.060	.723	.945	-1.531	1.439			
Lpos	(Constant)	3.093	.493	<.001	2.045	4.094	3.832	.003	.079
	EOT	.005	.012	.705	-.017	.026			
	DIF	-.019	.010	.066	-.039	.000			
	DDF	-.014	.014	.322	-.042	.013			
	SPS+	.148	.080	.068	-.007	.310			

DV	IVs	<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>F</i>	<i>p</i>	Adjusted <i>R</i> ²
					LL	UL			
Lneg	SPS-	.091	.047	.059	-.015	.191	10.142	<.001	.216
	(Constant)	1.528	.603	.012	.418	2.699			
	EOT	-.011	.016	.485	-.047	.025			
	DIF	.040	.014	.005	.015	.065			
	DDF	.033	.018	.070	-.004	.067			
	SPS+	.096	.101	.336	-.129	.287			
IFES	SPS-	-.019	.069	.774	-.144	.126	17.423	<.001	.331
	(Constant)	-17.763	9.473	.060	-37.315	-.090			
	EOT	.583	.240	.015	.133	1.107			
	DIF	.943	.232	.002	.502	1.389			
	DDF	-.025	.347	.947	-.671	.655			
	SPS+	4.788	1.663	.005	1.495	8.095			
	SPS-	2.401	1.207	.047	.103	4.911			

Note: Emotional Arousal of Positive Scenarios (EApos), Emotional Arousal of Negative Scenarios (EAneg), Vividness of Positive Scenarios (Vpos), Vividness of Negative Scenarios (Vneg), Intrusive Visual Imagery (IVI), Intrusive Verbal Thought (IVT), Likelihood of Positive Scenarios (Lpos), Likelihood of Negative Scenarios (Lneg), The Impact of Future Events (IFES), Externally Oriented Thinking (EOT), Difficulty Identifying Feelings (DIF), Difficulty Describing Feelings (DDF), Sensory Processing Sensitivity Positive Cluster (SPS+), Sensory Processing Sensitivity Negative Cluster (SPS-). 95% confidence intervals (95% CIs) were based on 1000 bias-corrected and accelerated bootstrap samples (LL = lower limit, UL = upper limit).

I had predicted that higher DIF, DDF, and/or SPS- scores would predict stronger ratings of the emotional arousal for negative imagery but, in fact, only lower EOT predicted this outcome when variance due to the other variables was controlled for. My second prediction was that higher SPS+ scores would predict stronger emotional arousal for positive imagery and for vividness ratings, overall. In fact, it was SPS- scores that predicted stronger emotional arousal for positive imagery. SPS+ and SPS- predicted stronger, and DIF weaker, vividness of positive imagery. Although the model predicting vividness of negative events was significant (suggesting that the variables collectively explained variance in the outcome), none of the individual predictors accounted for unique variance in these scores.

My third prediction was that DIF, DDF, and/or SPS- scores would be stronger predictors than EOT and/or SPS+ scores of aspects of FT such as experiencing intrusive visual imagery and verbal thoughts, ratings of the likelihood that negative events would occur in the future, and the perceived impact of future events. These predictions were again partially supported in that DIF accounted for unique variance in IVI, IVT, and likelihood ratings for negative events, and both DIF and SPS- scores predicted IFES scores. However, SPS+ scores also predicted higher IVI and IVT scores, and both EOT and SPS+ scores also accounted for unique variance in IFES scores. Although the model predicting likelihood ratings for positive events was significant, none of the individual predictors accounted for unique variance in these scores.

Objective 3: Exploring How Aspects of FT Relate to Depression and Anxiety

To explore this question, I ran separate hierarchical regression analyses predicting the severity of self-reported symptoms of depression and anxiety. In the first step of each analysis, I entered the mean ratings of the emotional arousal and vividness of positive and negative imagery produced in response to a cue as predictors. In the second step, I entered measures of how frequently intrusive images and thoughts occurred. In the third step I entered mean ratings for the likelihood of imagined positive and negative scenarios occurring as predictors. In the fourth and final step, I entered mean ratings for the anticipated impact of future events as a predictor.

The results of the regression predicting depression are presented in Table 4.4. All four models were significant, and the addition of new variables improved the overall model at each step, $\Delta R^2 \geq .032$, $p \leq .020$. At Step 1, the vividness of negative imagery predicted more severe depression symptoms, whereas vividness of positive imagery showed the opposite effect. At Step 2, IVT accounted for additional variance in depression scores. Once the likelihood ratings were entered at Step 3, vividness ratings no longer accounted for unique variance in depression.

Table 4.4*Relationships Between Future Thinking Variables and Depression*

IVs	<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>F</i>	<i>p</i>	Adjusted <i>R</i> ²
				LL	UL			
(Constant)	2.682	2.471	.277	-1.893	8.322	11.009	<.001	.194
EApos	2.144	1.010	.035	-.006	4.378			
EAneg	-.213	.884	.816	-1.875	1.469			
Vpos	-2.762	.989	.005	-4.693	-1.019			
Vneg	3.040	.842	<.001	1.301	4.788			
(Constant)	-2.322	2.454	.331	-7.208	2.425	14.219	<.001	.323
EApos	1.683	.982	.092	-.398	3.764			
EAneg	-.533	.800	.474	-2.027	.837			
Vpos	-2.209	.928	.021	-3.970	-.508			
Vneg	2.000	.807	.013	.376	3.719			
IVI	.116	.059	.053	-.001	.237			
IVT	.169	.061	.008	.040	.292			
(Constant)	-2.865	2.985	.323	-9.327	2.010	12.072	<.001	.348
EApos	1.682	.970	.081	-.454	3.787			
EAneg	-.787	.798	.310	-2.272	.631			
Vpos	-.961	1.168	.403	-3.414	1.159			
Vneg	1.035	.865	.230	-.711	2.917			
IVI	.095	.060	.109	-.021	.226			
IVT	.144	.061	.026	.018	.261			
Lpos	-1.061	.972	.277	-2.929	1.114			
Lneg	1.777	.703	.009	.449	3.245			
(Constant)	-2.740	2.762	.303	-8.554	2.005	13.212	<.001	.398
EApos	1.107	.917	.216	-.824	3.247			
EAneg	-.429	.783	.557	-1.955	.942			
Vpos	-.896	1.093	.403	-3.148	1.029			
Vneg	1.029	.840	.226	-.763	2.993			
IVI	.030	.060	.636	-.081	.142			
IVT	.080	.061	.200	-.040	.199			
Lpos	-.972	.915	.290	-2.681	1.131			
Lneg	1.629	.675	.012	.338	3.007			
IFES	.107	.031	.002	.050	.170			

Note: Depression (Dep), Emotional Arousal of Positive Imagery (EApos), Emotional Arousal of Negative Imagery (EAneg), Vividness of Positive Imagery (Vpos), Vividness of Negative Imagery (Vneg), Intrusive Visual Imagery (IVI), Intrusive Verbal Thought (IVT), Likelihood of Positive Scenarios (Lpos), Likelihood of Negative Scenarios (Lneg), The Impact of Future Events (IFES). 95% confidence intervals (95% CIs) were based on 1000 bias-corrected and accelerated bootstrap samples (LL = lower limit, UL = upper limit).

However, IVT and the likelihood of negative scenarios both positively predicted depression. At Step 4, only the likelihood of negative scenarios and the perceived impact of future events accounted for unique variance in depression, when controlling for all other factors.

The results for the regression predicting anxiety are presented in Table 4.5. All four models were significant, and the addition of new variables significantly improved model fit at steps 2 and 4, $\Delta R^2 \geq .060$, $p < .001$. At Step 1, the vividness of negative imagery predicted anxiety. At step 2, IVI and IVT scores accounted for unique variance in anxiety when the vividness of negative imagery was held constant. At Step 3, the addition of likelihood ratings did not improve overall model fit ($\Delta R^2 = .005$, $p = .522$) but IVI and IVT continued to account for unique variance in anxiety. Finally, at step 4, when controlling for all other factors only the perceived impact of future events accounted for unique variance in anxiety.

Discussion

The present study had three main objectives: 1) to examine how aspects of FT relate to one another; 2) to determine if the personality variables account for unique variance in aspects of FT; and 3) to explore how aspects of FT relate to depression and anxiety. The Discussion section is organized around these objectives.

Examining Relationships Between Aspects of Future Thinking

In addressing this objective, I found that participants rated cued positive scenarios as more vivid, emotionally arousing, and likely to occur than negative scenarios, overall. The latter finding suggests a general level of optimism in my study sample. Schacter et al. (2008) discussed that engaging in FT *can* encourage effective coping, emotion regulation,

Table 4.5*Relationships Between Future Thinking Variables and Anxiety*

IVs	<i>b</i>	<i>SE</i>	<i>p</i>	95% CI		<i>F</i>	<i>p</i>	Adjusted <i>R</i> ²
				LL	UL			
(Constant)	1.064	2.002	.590	-2.539	4.604	8.549	<.001	.154
EApos	.895	.798	.247	-.558	2.647			
EAneg	.679	.663	.308	-.617	1.966			
Vpos	-1.156	.715	.104	-2.566	.262			
Vneg	1.478	.654	.028	.029	2.838			
(Constant)	-3.786	2.304	.110	-8.334	.266	16.179	<.001	.354
EApos	.455	.751	.558	-.961	1.910			
EAneg	.360	.591	.524	-.807	1.490			
Vpos	-.635	.647	.336	-2.021	.814			
Vneg	.465	.637	.445	-.835	1.682			
IVI	.120	.044	.007	.034	.212			
IVT	.158	.041	<.001	.066	.245			
(Constant)	-3.634	2.952	.234	-9.773	.870	12.245	<.001	.351
EApos	.463	.760	.565	-.980	1.897			
EAneg	.303	.583	.600	-.825	1.413			
Vpos	-.177	.683	.783	-1.538	1.151			
Vneg	.167	.697	.816	-1.349	1.597			
IVI	.113	.045	.014	.025	.206			
IVT	.151	.042	.003	.056	.243			
Lpos	-.473	.718	.501	-1.831	1.290			
Lneg	.498	.597	.394	-.663	1.662			
(Constant)	-3.528	2.701	.206	-9.491	.679	13.858	<.001	.411
EApos	-.026	.743	.970	-1.415	1.462			
EAneg	.607	.623	.330	-.597	1.780			
Vpos	-.122	.650	.855	-1.437	1.126			
Vneg	.162	.686	.800	-1.297	1.604			
IVI	.057	.045	.215	-.028	.150			
IVT	.097	.044	.031	-.004	.190			
Lpos	-.397	.666	.534	-1.745	1.275			
Lneg	.371	.553	.514	-.687	1.409			
IFES	.091	.025	<.001	.047	.132			

Note: Anxiety (Anx), Emotional Arousal of Positive Imagery (EApos), Emotional Arousal of Negative Imagery (EAneg), Vividness of Positive Imagery (Vpos), Vividness of Negative Imagery (Vneg), Intrusive Visual Imagery (IVI), Intrusive Verbal Thought (IVT), Likelihood of Positive Scenarios (Lpos), Likelihood of Negative Scenarios (Lneg), The Impact of Future Events (IFES). 95% confidence intervals (95% CIs) were based on 1000 bias-corrected and accelerated bootstrap samples (LL = lower limit, UL = upper limit).

problem-solving, and an *optimism bias* (i.e., a positive event being perceived at a shorter temporal distance and being more intensely experienced than a negative event). However, they highlighted that individuals endorsing symptoms of depression or anxiety do not show this bias, a point that will be returned to later.

In line with past findings (López-Pérez et al., 2018), I also found that participants experienced more IVI than IVT. In addition, I found that (a) IVT was linked to reporting less vivid positive imagery about future scenarios; (b) that IVI was linked to reporting more vivid negative imagery about future scenarios; and (c) that both IVT and IVI were linked to reporting having thought about more negative than positive future events in the past week. These latter findings support the view that vivid images and thoughts of possible negative future scenarios are most likely to come to mind spontaneously, possibly reflecting rumination or worry.

I had also predicted that individuals who experienced more vivid negative imagery and more intrusive imagery (which is often negatively valenced) would endorse negative events as being more likely to occur. This hypothesis was partially supported. What I actually observed was that, whereas reporting more vivid negative imagery and more intrusive imagery predicted lower ratings of the likelihood of *positive* events, reporting more vivid negative imagery and more intrusive thoughts predicted higher ratings of the likelihood of *negative* events. These findings may reflect the operation of the availability and simulation heuristics (Kahneman & Tversky, 1982; Tversky & Kahneman, 1973). If one is able to generate vivid images about future negative events easily, and images and thoughts of these events are brought to mind more often than those relating to positive future events, this should bias estimates of how likely both negative and positive events are to unfold—albeit in different directions.

My final prediction was that individuals who reported more intrusive imagery and verbal thoughts, and who rated negative scenarios as being more likely to occur, would tend to feel that future events would have a larger impact on them. This hypothesis was again partially supported. IVI and IVT were significant positive predictors of IFES scores in my regression analysis, but I also found that, when controlling for other factors, it was the emotional arousal experienced during *positive* imagery that also predicted higher IFES scores. This latter finding may relate to the *fading-affect bias*, defined as the tendency for healthy individuals to experience a faster fading of negative than positive affect over time (see Walker & Skowronski, 2009). If those who experience high emotional arousal during positive imagery find that this arousal persists over time, that strong arousal may influence their ratings of the likely impact of future events. This effect should be most obvious in those reporting high levels of optimism. A body of literature has explored individuals' overall judgments about the future, with the consensus demonstrating that individuals are largely optimistic (e.g., Shao et al., 2010). However, Wang et al. (2014) found that individuals tend to expect challenges even when they have performed well previously (e.g., doing well academically in the past but not anticipating that they can uphold this level of achievement). Experiencing intrusive negative imagery or intrusive negative self-talk of this sort may serve to inflate estimates of how big an impact future negative events will have.

Do Facets of Alexithymia and/or SPS Account for Unique Variance in FT?

For objective 2, I had two sets of predictions. My first prediction was that higher SPS- scores would predict stronger emotional arousal for negative images, and that higher SPS+ scores would predict stronger emotional arousal for positive images and more vivid future-oriented imagery generated in response to a cue, regardless of whether positive or negative images were formed. Regarding emotional arousal, my hypotheses were not supported. I found

that (a) individuals scoring lower on EOT reported stronger arousal for negative imagery, and those scoring higher on SPS- reported stronger arousal for positive imagery. These effects may relate to the fact that low scores on EOT reflect turning attention inward, which may amplify emotional reactivity (Jakobson et al., 2024). Individuals scoring high on the HSPS are more emotionally reactive to both positive and negative stimuli (Aron et al., 2012) and show stronger behavioural (Jagiellowicz et al., 2016) and neural responses (Acevedo et al., 2014) when confronted with these stimuli.

Regarding imagery vividness, my hypothesis was partially supported. I found that both SPS+ and SPS- positively predicted vividness of positive imagery and that DIF negatively predicted these scores. These results are in-line with findings described in Chapter 3, where OS (a component of SPS+ traits) was found to be positively related to VVIQ scores. The link between SPS- traits and vividness of positive imagery seen in the present study is consistent with previous work linking emotional reactivity to positive imagery vividness (e.g., Wilson et al., 2018). The negative relationship I observed here between vividness of positive imagery and DIF could relate to Mantani et al.'s (2005) observation that individuals with alexithymia may not draw on long-term memory when constructing or evaluating the emotional significance of future happy events.

My second set of predictions was that DIF, DDF, and/or SPS- traits would be stronger positive predictors than EOT and/or SPS+ traits of intrusive FT, ratings of the likelihood of negative events occurring, and ratings of the impact of future events. However, I also expected that scoring low on EOT and/or high on SPS+ traits might still account for some of the variance in these measures. These hypotheses were partially supported. I found DIF was, in fact, a significant positive predictor of all of these outcomes. This aligns with Makino et al. (2013) who

highlighted that higher scores on DIF appear to involve a plethora of challenges with intrusive details, catastrophizing of scenarios, and ultimately concluding that negative things might occur in the future. The fact that individuals expressing stronger SPS+ scores also reported experiencing more intrusive visual imagery and verbal thoughts, and felt that future events would have a large impact, may relate to the fact that SPS+ traits are linked to frequent fantasizing and daydreaming and that strong expression of this trait cluster is also linked to deep processing (Jakobson et al., 2024). This can contribute to filing away rich memories that can influence simulations of the future (Ramanan et al., 2018).

High scores on EOT and SPS- traits also predicted ratings of the impact that future events might have. It is possible that the former effect arises because maintaining an outward focus limits one's conscious emotional experiences, making it harder to construct an accurate prediction of future feelings. This could bias one's estimates of the likely impact of future events. The latter effect was predicted and may relate to the fact that individuals scoring high on the SPS- cluster are particularly reactive to feelings of discomfort (De Gucht et al., 2022). For these individuals, it may not always be negative things that make them feel uncomfortable; indeed, as noted above, SPS- traits were linked to reporting higher emotional arousal for positive imagery in the present study. Imagining a positive event included in the PIT, such as "people will admire you," may elicit a strong emotional response in someone who is not used to or aspiring to be in a leadership role. Catastrophizing and ruminating over being made to feel uncomfortable in the future could result in one feeling that events in the future will have a big impact.

The results presented here provide ample evidence for the importance to researchers of more closely examining both SPS and alexithymia at a facet level when exploring future thinking. Furthermore, these findings have contributed to the literature exploring individual

differences in FT. Learning more about how facets of alexithymia and SPS interact with specific aspects of FT is important as it may help to explain some of the relationships between FT and mental health that I observed, which are described in the following section.

How Do Aspects of FT Relate to Depression and Anxiety in University Students?

My final objective was to explore links between self-report ratings of depression and anxiety and aspects of FT that may be shaped by SPS and/or alexithymia. For depression, I had four main predictions. My first prediction was that the emotional arousal and vividness of negative scenarios would predict greater depression severity while the emotional arousal and vividness of positive scenarios would do the reverse. This was partially supported. Emotional arousal did not account for unique variance in depression scores, but experiencing more vivid negative imagery and less vivid positive imagery both predicted higher depression severity in step one. These findings align with earlier reports. Thus, depressed individuals have been found to experience more vivid negative than positive imagery (López-Pérez et al., 2018) and Morina et al. (2011) found that, when depressed individuals were asked to imagine a positive future, they reported less vivid experiences.

My second prediction was that IVT, rather than IVI, would significantly improve the model and predict depression severity. This prediction was supported in step two. Other research has demonstrated that repeated negative thinking about past, present, and possible future experiences can impact an individual's appraisals of these events (e.g., Nolen-Hoeksema et al., 2008). Repeated negative thinking in depression may persist even after treatment concludes (Nierenberg et al., 2010), suggesting how big an impact it can have.

My third and fourth predictions were that the estimated likelihood of negative scenarios would significantly improve prediction of depression in step three, while the anticipated impact

of future events would significantly improve prediction of depression in step four. Both of these predictions were supported and in-line with research demonstrating that individuals with depression have a default cognitive style that includes a pessimistic attitude toward the future (MacLeod et al., 1997), and rate negative events as more likely to occur than positive events (MacLeod & Cropley, 1995) and future events as having a greater impact on them (Morina et al., 2011). Roepke and Seligman (2016) posited that a vicious cycle emerges when an individual with depression assumes negative things will occur and has difficulty with flexibility when thinking about the future, and that these interactions may result in poorer functioning overall.

Regarding anxiety, I had four main predictions. My first prediction was that emotional arousal and vividness of negative imagery would predict anxiety ratings. Only vividness of negative imagery was a factor, but the importance of this variable was also highlighted in a meta-analysis completed by Du et al. (2022). In my results, the impact of vividness may be overshadowing the impact that emotional arousal has in predicting anxiety.

My remaining predictions were that, after accounting for variance in arousal and vividness of imagery, IVT, ratings of the likelihood of negative scenarios, and the impact of future events would each significantly improve the model predicting anxiety. These predictions were partially supported. In keeping with Morina et al. (2011) my results suggest that both intrusive thoughts and intrusive images are important predictors of anxiety. Research into these types of intrusions suggest that they can influence cognitive avoidance in anxiety disorders such as obsessive-compulsive disorder (Rachman, 2007), and encourage negative thinking (Ng et al., 2014). Although accounting for ratings of the likelihood of negative scenarios occurring improved the overall model at the next step, this variable did not account for unique variance in anxiety when other potentially relevant variables were controlled. In anxious individuals,

intrusive negative images and thoughts may prompt the use of strategies such as cognitive avoidance (Gústavsson et al., 2021), even if these individuals do not believe that negative situations are likely to occur. Negative thinking and avoidance could also inflate ratings of the impact that future events may have; in the final model, only these ratings accounted for unique variance in anxiety.

Strengths and Limitations

The present study had many strengths, including the use of psychometrically robust self-report measures. Moreover, my findings highlighted the importance of taking a facet-level approach to dissecting variance accounted for by alexithymia and SPS when studying their links to FT, and of exploring how specific aspects of FT relate to mental health. Despite these strengths, this study also included limitations, while also offering new paths for future research to explore.

First, the severity of anxiety and depressive symptoms were each assessed through the use of a brief questionnaire. Future researchers may wish to utilize additional measures or to employ diagnostic interviews to assess the severity of symptomatology. In research involving clinical samples, it would also be interesting to add a treatment component where participants are provided CBT to encourage the use of positive imagery, and then to reassess symptomatology, and perceived impact of future events.

Second, previous work in our lab has employed techniques such as latent profile analysis to identify individuals displaying subtypes of alexithymia that differ with regard to the expression of traits associated with SPS (Jakobson, & Rigby, 2021). Future researchers may wish to use this approach to determine if these subtypes differ with regard to aspects of FT, in addition to their mental health. Large samples are required for this type of analysis.

Lastly, future researchers may wish to replicate this study but have participants undergo fMRI when generating positive and negative images of possible future events. Mantani et al. (2005) demonstrated reduced activation in the posterior cingulate cortex when alexithymic individuals were imagining past and future happy events relative to activity seen at rest, and when imaging future happy events relative to when imagining future negative events. However, in the present study facets of SPS proved to be more important predictors than facets of alexithymia of the emotional arousal and vividness of positive imagery.

Conclusions

This study expands our understanding of how different aspects of FT relate to one another. It also provides important, novel insights into the ways in which specific facets of SPS and alexithymia relate to individual differences in aspects of FT that appear to impact the severity of depression and anxiety experienced by university students. These insights could inform the development of individually tailored treatments for these common mental disorders, an idea that I will explore in more detail in the final chapter of my dissertation.

CHAPTER 5: KEY FINDINGS AND CLINICAL IMPLICATIONS

My doctoral dissertation contributes to the body of literature investigating links between individual differences in imagery and simulation-based processes. My findings across all studies provide novel insights into default strategies that individuals appear to utilize; biases that may impact mental rotation, emotion anticipation, and future thinking; and how common mental health disorders may alter or be impacted by these processes.

Summary of Key Findings from Each Study

In Chapter 2, I used an HLT to demonstrate that individual difference variables are important factors in understanding default imagery strategies. I showed that individuals appear to utilize different strategies depending on their level of SPS. More specifically, when completing an HLT, individuals scoring high, versus low, on SPS appear to employ motor imagery broadly, rather than simply when it may be more efficient to do so. Despite my results suggesting that mean RT on correct trials predicted anxiety severity, once my personality variables were entered into the model this effect was eliminated, suggesting that factors related to personality underlie this effect. This highlights the importance of considering individual difference variables when examining interactions between performance-based variables and mental health.

In Chapter 3, I had participants rate neutral faces appearing at the end of sequences depicting fading anger or joy. Here, I successfully replicated an overshoot effect by showing that faces at the end of joy-to-neutral sequences were rated as slightly angry, while faces at the end of anger-to-neutral were rated as slightly joyful. When an identity change was implemented, these overshoots were abolished, providing evidence that they reflected a mentalizing or EA effect. I also explored how individual differences associated with SPS, alexithymia, anxiety, and depression are linked to anticipatory biases in how we represent expressive faces in working

memory. In doing so, my results suggested that the higher one's OS scores, the more likely one was to mentalize—particularly regarding the likelihood that another's mood was about to undergo a negative shift. Preliminary evidence was obtained that individuals reporting stronger symptoms of anxiety and depression who reported strong signs of orienting sensitivity showed somewhat stronger anticipation of negative shifts than those reporting weak signs of this feature of SPS. Learning more about how individual difference variables and mood relate to predictive processes that appear to affect how we interpret subtle changes in another's facial expressions is imperative as these EA effects could have important implications for how social interactions may play out.

In Chapter 4, I used a survey-based approach to investigate relationships between different aspects of FT, their links to specific facets of personality, and how they relate to mental health. I reported several noteworthy findings. First, positive imagery was rated as more vivid, more emotionally arousing, and more likely to occur than negative imagery. Second, participants who experienced vivid negative imagery also reported experiencing more IVI and IVT. Third, I found that participants reported more IVI than IVT, overall. Fourth, IFES scores were positively predicted by emotional arousal elicited by positive imagery, and by both IVI and IVT. In addition to these results, I found that specific facets of alexithymia and/or SPS predicted virtually all of the FT variables, which were later found to be implicated in mental health. Finally, I found that, with all other FT variables held constant, the likelihood of negative scenarios and perceived impact of future events were the strongest predictors of depression, and the perceived impact of future events was the strongest predictor of anxiety.

The findings from the three studies presented in my dissertation have demonstrated the importance of considering individual differences in SPS and alexithymia when exploring how

mental imagery and simulation-based processes relate to mental health. The findings presented in Chapters 3 and 4, in particular, also provide some insight into how these personality traits relate to negativity biases, such as those impacting threat assessments or judgments regarding the likelihood of negative events occurring. The important clinical implications of these results is the topic that I turn to next.

Clinical Implications

Mental imagery and simulation-based processes have been shown to have a significant impact on mental health, and specifically on anxiety and mood disorders (Pearson et al., 2013). Furthermore, mental imagery that is intrusive in nature is seen across several diagnostic categories beyond that of anxiety and mood (e.g., trauma-related disorders, eating disorders, bipolar, psychosis; Brewin et al., 2010). This demonstrates the broad range and reach that mental imagery can have on an individual's well-being. The following sections will focus on how clinicians might apply knowledge regarding how individual differences in motor imagery, emotion anticipation, and future thinking may impact mental health to increase the effectiveness of their clinical interventions—particularly when working with clients who score high on SPS and/or alexithymia.

Therapeutic Approaches Involving the Use of Motor Imagery

One treatment that has been effective in the treatment of anxiety disorders has been exposure therapy (e.g., see meta-analysis by Norton & Price, 2007); however, not all individuals are able to engage in exposures in person at a frequency that would be clinically beneficial (e.g., exposure to flying). Similarly, behavioural activation, which involves gradually encouraging individuals to engage in activities that provide a sense of pleasure or accomplishment, has been shown to be effective in the treatment of depression (Dimidjian et al., 2006), but some may not

be physically able to increase their engagement due to mobility difficulties or chronic pain, for example. In situations such as these, motor imagery could serve as an effective, alternative modality for providing treatment to individuals.

Lang's (1979) work laid the groundwork for how imagery-related interventions should be structured and this influenced the development of Holmes and Collins' (2001) *PETTLEP* model, which identifies components that should enhance the effectiveness of motor imagery interventions, including: Physical state, Environment, Task, Time, Learning, Emotion, Perspective. Specifically, in their model imagery tasks should address: (a) the physical state of an individual (including, for example, things such as their body posture); (b) the environment that is imagined (i.e., the place and other details of the scene); (c) the task that the individual has to imagine engaging in; (d) how slowly or quickly the individual should imagine moving when completing the task within the scene; (e) adjusting the difficulty of activities as learning proceeds; (f) the emotion elicited by the motor imagery (i.e., mimicking the emotions felt when actually engaging in the activity); and (g) the perspective that the individual adopts (i.e., whether a first-person or third-person perspective is adopted). The goal is to ensure that imagery is as similar as possible to experiences in real life.

Subsequent work has supported the idea that variables in the PETTTLEP model are important to consider when trying to maximize the effectiveness of motor imagery interventions. For example, Bradley et al. (2023) completed a review of the history and development of treatments involving exposure to feared stimuli, including those based on tenets of the bioinformational theory (Lang, 1979). In their review, they note that fMRI research suggests that overlap with activations seen in motor regions in the brain during actual movements is more evident when the individual imagines engaging in the activity from a first-person perspective

(i.e., being the person swimming) rather than being an observer (i.e., imagining watching someone else swim laps). Therefore, Bradley et al. (2023) suggested that having one's client adopt a first-person perspective when using motor imagery in exposure treatments might improve efficacy.

Hu et al. (2025) completed a review of motor imagery interventions aimed at targeting cognitive processes to reduce pain perception, promote positive experiences, engage motor and emotional functions, and decrease symptoms of depression. The interventions reviewed included imagining completing various physical tasks (e.g., activities of daily living, Tai Chi), exercises (e.g., contracting the spine, walking), and interactions with others (e.g., hand shaking, observing facial expressions), and performing relaxation exercises (e.g., imaging the sea or beach). These interventions were administered through a plethora of modalities—virtually, face-to-face, and via video clips and CDs. The treatments were intended to simulate behavioural activation by recruiting similar movement-related systems as an initial step in developing agency in depressed individuals. Indeed, motor imagery was shown to lead to significant reductions in depressive symptoms in approximately half of the studies. Importantly, however, of the studies reviewed, only two addressed all of the elements of the PETTLEP model, suggesting that further refinements to these techniques could be made to increase their effectiveness.

Certain components of the PETTLEP model—in particular, the environment, the emotions elicited during imagery, and the pacing—may be especially important to consider when tailoring exposure or behavioural activation interventions for individuals with alexithymia and/or SPS. However, over half of the studies reviewed by Hu et al. (2025) did not address these particular components. For individuals scoring high on SPS, who are prone to overstimulation, emotionally reactive, and have low pain or physiological symptom tolerance (Aron, 2013), the

environment and emotions elicited by the imagery may be especially important. Clinicians may be wise to titrate the intensity of emotions imagined to provide the individual with confidence that they can tolerate the exposure across a range of settings. In contrast to those with SPS, individuals with alexithymia often seek out strong forms of stimulation (e.g., through engagement in high-risk and competitive sports; see Barlow et al., 2015; Proença Lopes et al., 2022), possibly as a way to increase their awareness of their internal state and their emotions. Having these individuals engage in muscle relaxation prior to performing a motor imagery task may help them to turn their attention inward, building their capacity to benefit from therapy (e.g., Trapero-Asenjo et al., 2025).

The pacing of an imaginal exposure may also serve as an important variable in therapy for individuals with SPS or alexithymia who display psychomotor slowing, which is a common symptom of depression. Paquet et al. (2022) noted that psychomotor slowing is often accompanied by an aversion to seeking out environmental stimulation. Jakobson and Rigby (2021) found that this aversion was very common in highly sensitive individuals who also scored high on all three key features of alexithymia. Individuals with this particular personality profile may benefit not only from slowing the pacing of imagined activities but also by titrating the intensity of imagined environmental cues.

Therapeutic Approaches to Address Biases Related to Emotion Anticipation

Symptoms of anxiety and depression might alter how information is experienced and interpreted in the moment. For example, anxious individuals have been shown to perceive ambiguous stimuli as concerning and dangerous (Grupe & Nitschke, 2013). Previous research has also shown that depressed individuals require less intense cues to identify sad than angry expressions, and stronger cues in order to correctly identify positive expressions (Joormann &

Gotlib, 2006). Moreover, biases in the identification of positive expressions persist during remission of symptoms (LeMoult et al., 2009).

In my EA study, I found that those with stronger symptoms of anxiety and depression were more sensitive to the possibility of an upcoming shift in another's facial expression, as demonstrated by exhibiting larger EA effects. Villiger (2025) explains that in predictive processing, which presumably underlies EA effects, the brain tries to predict incoming sensory information in a top-down manner (e.g., based on beliefs). He argues that repeated errors in predictive processing results in the development of psychopathology. For example, if you expect that someone will be nice to you and multiple individuals continually make fun of you instead, your brain updates the belief that individuals are unkind. With this update, you may begin to experience low mood and depressive symptoms and begin to withdraw from social interactions. Villiger (2025) also explains why psychotherapy is effective in the treatment of mental health disorders: tenets of the therapeutic alliance (e.g., positive regard, empathy) alongside cognitive restructuring (an element of CBT) help to counteract errors in predictive processing. His Predictive Processing Model of Psychotherapeutic Interventions was developed to show how common (i.e., therapeutic alliance) and specific (i.e., technique utilized) factors in therapy can be integrated to reshape predictive processes that lead to errors.

Harris (2025) suggested a complementary model to describe how certain therapeutic approaches can impact how the brain engages in predictive processing. In the Active Intersubjective Inference model, individuals learn about themselves through inferences they make about how others perceive them. This learning is constantly being updated by feedback that the individual receives (in vivo) or by feedback that the individual thinks they will receive (imaginal) and influences their actions and beliefs. Harris (2025) argues that this framework

hinges on the free energy principle, according to which individuals making choices that minimize errors in perception (Friston, 2010; Friston et al., 2017). For example, if invited to attend a party where you have no close friends and may therefore experience scrutiny, free energy principle states that you might opt to avoid the party and stay home (i.e., choose safety). Although the intricacies and neural mechanisms are beyond the scope of the current paper, Harris (2025) suggests that looking at the model through a psychodynamic lens can provide insight into an individual's psychopathology. For example, depressive or anxiety might be seen as arising from rejection experienced by caregivers in childhood that manifests in cautious responding to others later in life, resulting in withdrawal from social interactions and activities due to fear or fatigue. The author suggests that clinicians can utilize psychodynamic therapy to target the root of perceived threats, and to increase flexibility in how threats may impact one's self-model.

Other treatment modalities have been suggested to treat maladaptive responses to ambiguous threat. For example, LeMoult and Gotlib (2019) suggest that CBT has been shown to be effective in reducing negative attention biases (i.e., away from perceived threat), in interpreting ambiguous information more positively, and in increasing perceived control over one's symptoms. Additionally, they comment on mindfulness specifically as an intervention that can be effective in reducing rumination tendencies and overgeneralization of autobiographical memory. Interestingly, recent research on mindfulness has also shown it to be an effective intervention at improving the detection of sad and angry faces (Bi et al., 2024). In reducing the impact of these variables, individuals are better able to improve negative mood states (Joormann et al., 2007).

Incorporating mindfulness into body relaxation techniques may be particularly useful when treating clients who score high on OS, as I found that this component of SPS was associated with showing stronger mentalizing tendencies, and that this may have contributed to an increased tendency to anticipate possible negative shifts in others' feelings. Takahashi and Ogishima (2021) suggest that mindfulness can assist in reducing prediction errors by calming the system and subsequently re-evaluating the sensation to match the prediction. Said differently, mindfulness can be beneficial in making decisions once the affect related to the decision has dissipated.

Incorporating mindfulness into body relaxation techniques may also be indicated when treating the symptoms of depression, anxiety, and anxiety sensitivity that highly sensitive individuals and those with alexithymia are at particularly high risk for experiencing (Van Landeghem & Jakobson, 2024). For example, Lalande et al. (2017) found that guided respiration mindfulness therapy led to significant reduction in these symptoms.

As a final note, it has been shown that alexithymic individuals experience a more challenging time connecting with their therapist, and forming a strong therapeutic relationship (Quilty et al., 2017). As errors in predictive coding may contribute to these difficulties, some of the approaches described above may help to improve this relationship. In addition, Darrow and Follette (2014) suggested that behavioural interventions can be helpful and effective for clients with alexithymia. Virtual reality may be another treatment modality that can be helpful, as virtual reality assists individuals to come into contact with stress-provoking stimuli and to reduce avoidance of emotions, two areas that may benefit alexithymic individuals (Preece et al., 2017). Whatever treatment course is undertaken, it is important that clinicians take their client's

experiences into consideration and employ a treatment plan that the individual agrees to, as this will help to strengthen the therapeutic relationship.

Therapeutic Approaches to Address Biases in Future Thinking

The brain is constantly assessing both present and possible future situations to tell the body how best to respond. It does this by drawing on past experiences to make inferences about what may occur based on that learning. The *Active Inference* framework suggests that individuals are attempting to be as close as possible to being right, and to reduce the discrepancy between their prediction and the sensations that they experience in the body (Friston et al., 2009).

However, depressed individuals may evaluate this discrepancy differently from those who are not depressed. Specifically, according to this framework, depressed individuals dampen the weight of positive experiences and overweigh negative experiences in making their predictions, resulting in a negative bias that could impact their actions and beliefs. Consistent with this, Feldmann et al. (2023) found that when given false negative feedback about their performance in a task, individuals scoring high on depression lowered their expectations more than those scoring low on depression in the next block of trials. Moreover, following positive feedback, individuals scoring high on depression increased their expectations less than those scoring low on depression in the next block of trials.

Hopelessness has been characterized as another pertinent variable for clinicians to consider when exploring factors related to depression (MacLeod & Salaminiou, 2001), suicidal behaviour (Conaghan & Davidson, 2002), and expectations about the future including lack of motivation (Beck et al., 1974). High levels of hopelessness have also been seen as a major risk factor in individuals who engage in self-injurious behaviours without the intent to end their life, often referred to in the literature as parasuicidal behaviour. For example, Conaghan and

Davidson (2002) found that both parasuicidal and depressed older adults reported less positive future thinking than a community control group.

Anhedonia, described as the blunting of affect and reduction of pleasure, is often a treatment resistant symptom of major depressive disorder. Hallford et al. (2023) stressed the importance of targeting this symptom in therapy by helping clients to think more positively about the future and by addressing challenges in creating specific future-oriented images. Their Future Event Specificity Training protocol encompassed two sessions that included psychoeducation (e.g., regarding future thinking, depression, how they interact, general future thinking, specific future thinking, conscious control), practice at generating specific future situations that would occur or have a high likelihood to occur, and practice of the same. The researchers found that the Future Event Specificity Training protocol improved specificity, detail, and perceived control over the likelihood of the future events occurring. Moreover, individuals who completed the Future Event Specificity Training protocol were less likely to continue to meet the anhedonia criterion. These effects were robust and evident at both the 1-month and 3-month follow-up. This demonstrates the importance that specificity has in future thinking, and the impact it can have on depressive symptomatology.

It can also be helpful for clinicians to view anxiety and stress from an Active Inference framework. Anxious individuals are more likely than less anxious individuals to mentally ruminate on possible negative experiences, especially those likely to occur in the near future; some research suggests that they exhibit a pessimism bias, anticipating that negative events will come to fruition (Hoerger et al., 2012). It is therefore important to address this in therapy. As anxiety generally involves worry about a future situation, engaging in positive future thinking can help mitigate anxiety symptoms. Indeed, Brown et al. (2002) argued that shifting an

individual's attention toward an idealized self, as well as having individuals imagine resolving a future scenario positively, leads to an increase in positive affect and a reduction in worry.

Smith et al. (2021) reference the Active Inference framework when describing how avoidance can reinforce negative predictions (e.g., spiders are dangerous and avoiding them keeps me safe). They also describe CBT as an effective intervention in challenging these predictions and managing fear and uncertainty, rather than attempting to eliminate it. In this way, exposure to stimuli is used to update predictions, and cognitive restructuring is used to balance automatic thoughts regarding threat versus safety to improve tolerance to uncertainty. Clinicians may also want to address episodic foresight (the ability to generate future-oriented images) to address maladaptive patterns of avoidance. Miloyan et al. (2016) note that, through one's own biases or overgeneralization of one's negative experiences, episodic foresight can result in an individual concluding that it is safer to avoid a potentially negative situation. They argue that using imagery-based exposure regarding a future feared situation can assist in reducing its impact. Moreover, and as Bradley et al. (2023) suggested, having individuals adopt a first-person perspective may further enhance the efficacy of treatment.

Some of the clinical interventions mentioned above may be particularly helpful when working with clients with alexithymia and/or SPS. In my FT study, I found that DIF was associated with low vividness of positive imagery regarding future events. This was noteworthy as experiencing less vivid positive imagery predicted greater depression severity. Therefore, interventions that increase the vividness of simulated positive future events, such as those that incorporate Future Event Specificity Training or the use of virtual reality, might prove especially helpful for those scoring high on DIF. Habak et al. (2021) utilized a virtual reality program to provide positive reinforcement to individuals as they explored the scene. For example, opening a

door was rewarded with positive imagery (e.g., tropical beaches) with an accompanying sensory experience (e.g., a warm breeze). The idea they proposed is that the experience provides a sense of positive anticipation as they continue to explore the space. Their findings highlighted a reduction in hopelessness, improved mood and well-being, and a reduction in negative mood.

I also found that both IVI and IVT were more common in those reporting greater DIF or stronger expression of SPS+ traits. This suggests that IVI (which predicted anxiety) should be important target in therapy for those exhibiting these features, as it can contribute to significant dysfunction in daily life. For example, a commentary by Pighin and Tentori (2021) suggests that individuals who are engaged in a lot of spontaneous mental simulation (a characteristic of those scoring high on SPS+ traits) might be impacted negatively by IVI when needing to make medical decisions. Consider a client about to undergo surgery. A highly sensitive individual may experience very distressing future-oriented IVI (e.g., details of the surgery or recovery, risk of error during the procedure) that deters them from undergoing treatment. As previously mentioned, virtual reality might be one approach a therapist could use to promote positive imagery and reduce worry in cases such as this. Some preliminary support for this comes from work of Sommer et al. (2024) who utilized a virtual reality program to expose breast cancer patients to the operating room environment. In addition, Zhou et al. (2023) had post-operative breast cancer patients engage in a virtual reality rehabilitation program that focused on exercises to promote recovery (e.g., pain relief). Participants in the Zhou et al. (2023) study reported improved mobility, improved mood, and reduced stress levels as a result of the program. Although virtual reality is still in the earlier days of clinical use, it appears to be a strong contender for practice with exposure.

It may also be particularly important to address the high levels of IVT seen in clients scoring high on DIF and/or SPS+ traits, given that I found IVT to be a predictor of both anxiety and depression. Amano et al. (2023) demonstrated that CBT and traditional talk therapy were equally effective in reducing depressive symptoms and increasing positive (rather than negative) responses to future-oriented questions. A variant of CBT that is specifically designed to target rumination as a cognitive vulnerability factor for depression and anxiety (rumination-focused CBT) has also been found to be effective (Umegaki & Koto, 2025). Future Event Specificity Training (Hallford et al., 2023) may also be helpful in developing a client's perceived control over the likelihood of the negative future events occurring.

Acceptance and Commitment Therapy (ACT), which has been shown to be an influential therapeutic modality in treating anxiety and depression (Twohig & Levin, 2017), may be a useful approach that could also address the increased tendency I observed for those scoring high on DIF to see negative events as being likely to occur. In fact, Larsson et al. (2016) found that individuals who engaged in defusion from negative thoughts (a component of ACT) rated negative thoughts as less believable than individuals who engaged in cognitive restructuring (a component of CBT) or those in a control group. This demonstrates the effectiveness that ACT may have in finding relief from negative thoughts, overall.

My finding that the perceived impact of future events was strongly predicted by aspects of both alexithymia and SPS suggests that this is yet another area that may require special attention in treatment, as these traits are both associated with catastrophizing (Lumley et al., 2002; Yano & Oishi, 2024). The tendency of individuals with SPS to process stimuli deeply (Aron et al., 2012) may be a factor that contributes to their tendency to inflate the likely impact of future events. As such, mindfulness-based approaches aimed at helping them to stay “in the

moment” may be particularly useful. Mindfulness practice may also help those scoring high on SPS and/or alexithymia to process and regulate emotional reactivity more effectively, as it involves the intentional focusing of attention on body sensations, thoughts, or feelings (Bishop et al., 2004). Finally, this type of intervention may also help individuals expressing these traits to develop more insight into what they might be feeling about an imagined future event (e.g., happiness, apprehension, worry, sadness).

Directions for Future Research

Although the preceding discussion provides some suggestions for tailoring interventions with the goal of enhancing their effectiveness with highly sensitive individuals, more work is needed. This is especially true when considering highly sensitive clients who have a history of experiencing early adversity, as these individuals tend to show a weaker response to treatment than those raised in more supportive environments (see de Villiers et al., 2018). In contrast, highly sensitive individuals who were raised in supportive environments may demonstrate more growth in treatment than those raised under more adverse conditions due to positive coping when faced with stressful situations (Aron et al., 2012). Additional work is needed to determine how best to capitalize in therapy on features of SPS that can contribute to resiliency (see De Gucht et al., 2024; McQuarrie et al., 2025).

It is noteworthy that interventions used in the treatment of disorders such as anxiety and depression that specifically target alexithymia can not only improve clients’ mental health but also lead to reductions in the strength of self-reported features of this trait, suggesting that there may be some state-dependent variation in its expression (e.g., see meta-analysis by Cameron et al., 2014; Sagar et al., 2021). Although Cameron et al. (2014) concluded that no particular psychotherapy treatment was judged to be superior, they did suggest that CBT might be effective

due to the structured nature and support that is provided during cognitive restructuring or exposure work. Through this type of work, alexithymic individuals are provided a supportive environment to begin to expand their knowledge and understanding of their own emotional world. Cameron et al. (2014) also noted that many current approaches to target alexithymia involve the use of group therapy as a modality. In a group context, individuals with alexithymia may be able to model and receive feedback from other participants. They may also feel less pressure to speak and instead to be comfortable being an observer.

It is important to remember that SPS and alexithymia commonly co-occur (e.g., Van Landeghem & Jakobson, 2024), and that more work is needed to better understand what types of treatment modalities would best help this population. Therefore, we must continue to expand our understanding of how different facets of these traits may interact, and how that might inform case conceptualization and treatment planning. Perhaps most important is an ongoing assessment of the therapeutic alliance with this population, as maintaining a strong and healthy alliance is a key factor in successful treatment (e.g., see Wampold, & Imel, 2015). Therapists also need to manage their own countertransference (the unconscious redirection of feelings, attitudes, or desires from the therapist's own past relationships or unresolved issues onto the client)—especially in cases where they anticipate that a client displaying SPS and/or alexithymia will make slow progress (e.g., Cameron et al., 2014).

Concluding Remarks

The studies included in my dissertation make important, novel contributions to the literature by exploring how alexithymia and SPS interact with imagery and simulation-based processes in ways that may affect risk or resiliency for common mental health difficulties. By screening for traits such as alexithymia and SPS, clinicians could be provided with information

that may prove crucial in developing an effective, individualized treatment plan aimed at helping their clients meet their goals and reduce the impact and severity of psychopathology. The results presented in this dissertation should be built upon in future research to continue to expand our understanding of these traits and the treatment approaches that would be most beneficial to them.

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Appendix

Prospective Imagery Test – Items for Positive and Negative Scenarios

Positive items:	Negative items:
You will be very fit and healthy	You will have health problems
You will make good and lasting friendships	Someone close to you will reject you
People you meet will like you	People will dislike you
You will do well on your course	People will think you're a failure
You will have lots of good times with friends	You will be excluded by friends
Your mind will be very alert and "on the ball"	You will make a lot of mistakes
You will achieve the things you set out to do	Things won't work out as you had hoped
You will have lots of energy and enthusiasm	You will become tired and lethargic
People will admire you	People will find you dull and boring
You will be able to cope easily with pressure	You will be unable to cope with your responsibilities