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PSYCHOLOGICAE
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MARTIN KOLNES

Appraisal driven modulation of attention control

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Appraisal driven modulation of attention control

UNIVERSITY OF TARTU
Press

Institute of Psychology, University of Tartu, Estonia

The dissertation has been accepted for the commencement of the degree of Doctor of Philosophy (in Psychology) on October 3, 2022 by the Council of the Institute of Psychology, University of Tartu.

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Commencement: December 16, 2022 in Näituse 2, Tartu

Publication of this thesis is granted by the Institute of Psychology, University of Tartu

ISSN 1024-3291 (print) ISSN 2806-2531 (pdf)
ISBN 978-9916-27-045-5 (print) ISBN 978-9916-27-046-2 (pdf)

University of Tartu Press
www.tyk.ee

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LIST OF ORIGINAL PUBLICATIONS

I. **Kolnes, M.**, Naar, R., Allik, J., & Uusberg, A. (2019). Does goal congruence dilate the pupil over and above goal relevance? *Neuropsychologia, 134*, 107217. https://doi.org/10.1016/j.neuropsychologia.2019.107217

II. **Kolnes, M.**, Gentsch, K., van Steenbergen, H., & Uusberg, A. (2022). The mystery remains: Breadth of attention in Flanker and Navon tasks unaffected by affective states induced by an appraisal manipulation. *Cognition & Emotion, 36*(5), 836–854. https://doi.org/10.1080/02699931.2022.2056580

III. **Kolnes, M.**, Uusberg, A., & Konstabel, K. (2021). On the relationship between explicit and implicit self-concept of extraversion and neuroticism. *Journal of Research in Personality, 90*, 104061. doi:https://doi.org/10.1016/j.jrp.2020.104061

IV. **Kolnes, M.**, Uusberg, A., & Nieuwenhuis, S. (submitted). Broadening of attention dilates the pupil.

The author of the present dissertation contributed to all the publications in a similar way. The author developed the design, conducted the experiments, carried out the data analysis, and wrote the manuscript as the main author.

1. INTRODUCTION

When solving a difficult task, it is common for attention to become narrowly focused. For example, a novice driver, driving for the first time in a new city, may become entirely absorbed in their task, even without noticing the sounds of their radio, or the comments of their vehicle's passengers. There are several reasons why this phenomenon may occur. Firstly, the focus that the driver experiences can stem from their cognitive effort: the driver may attempt to recall, for example, an exact route to their destination, or the meaning of the street signs that appear throughout the journey. Secondly, the focus may be the result of a more affective underlying mechanism: this may be caused by, for example, the driver becoming frustrated with the act of driving in an unfamiliar city. Thirdly, and even more likely, the attentional focus may stem from a mix of cognitive and affective factors. In this dissertation, I will discuss the last of these three possibilities, the interaction between affect and cognition and how this interaction informs the attentional process.

Historically, *affect* and *cognition* have been treated as distinct mental faculties; however, this view is not supported by contemporary research. The term affect refers to processes that give subjective quality to a given experience and prepare the organism's response to it. As such, it refers to a broad range of feeling states, including emotions and moods (Gable & Harmon-Jones, 2010b; Naragon-Gainey, 2018). The term cognition refers to mental process that deal with acquisition, storage, retrieval, and processing of information, such as attention, memory, language, and problem solving (Bayne et al., 2019). From a folk psychology perspective, the distinction between affect and cognition is understandable, as the subjective experience of affective and cognitive processes are quite different. Affective states are often associated with discrete feelings, such as anger and happiness, which can seem uncontrollable, often irrational, and thus in conflict with "reason"(Berridge, 2018). Differently from affect, cognition is associated with controlled and rational behaviour. This makes it seem like affect and cognition are not just distinct processes but almost the opposites of each other.

Contemporary psychological science, however, has highlighted that the difference between affect and cognition is not as clear-cut as traditionally thought. Instead, affect and cognition are viewed either as separate but interacting phenomena or as inseparable. Espousing the first view, many researchers consider affect and cognition as systems that can mutually influence one another (Storbeck & Clore, 2007). For example, affect arising from distressing events can influence attentional processes by causing tunnel vison, meaning that attention is focused only on the most threatening stimuli in the environment (Kensinger, 2009). On the other hand, in an emotional setting, such as giving a speech in front of an audience, focusing attention on the non-emotional aspects of the situation can help to regulate one's emotions (Gross, 1998).

Researchers who view affect as inseparable from cognition argue that the difference between affect and cognition is only phenomenological, and that ontologically there is no difference between them (Duncan & Barrett, 2007). This means that the distinction stems from the subjective experiences that are attributed to affect and cognition, with the underlying mechanisms of the processes intertwined and overlapping. For instance, brain regions that have traditionally been considered "affective" and "cognitive" turn out to contribute to both affective and cognitive phenomena (Okon-Singer et al., 2015; Pessoa, 2012).

In this dissertation, to understand the relationship between affect and attention control, I will rely on the idea that affect and cognition are tightly connected phenomenon. More specifically, I will examine the role of cognitive appraisals, a fundamental component of affect, in driving attention control. I will first give a short overview of visual attention control, focusing on attention allocation and breadth of attention. Next, I will discuss more specifically the nature of affect and introduce appraisal theory of emotion, which posits that cognitive appraisals are a key part of affect generation (Moors et al., 2013). Then I will present pupil dilation as a unique and objective measure of attention control processes. In the first empirical study, I will investigate whether pupil dilation coincides with breadth of attention. After that, I will shift the discussion to affective influences on attention control. In the second study, I will investigate the effects of two appraisals, goal relevance and goal congruence appraisal, on attention allocation measured via pupil dilation. Next, I will present the argument that appraisal, besides influencing attention allocation, could also shift breadth of attention. In a two-experiment study, I will investigate this question with two different breadth of attention measures. Finally, I will argue that future research in this field could benefit from taking into account individual differences, especially the extraversion and neuroticism traits of personality. I will also argue that using implicit measures of personality, besides the classical self-report measures, could provide additional insight into the aspects of personality that are connected to affective reactivity. In the final study, I will examine whether the self-report and implicit measures of personality reflect the same aspects of the personality dimension or distinct aspects.

1.1. Attention control

Attention control involves bringing about prioritized processing of some stimuli relative to others. I will focus here on visual attention. Like most of our senses, at any given time, our visual system has to deal with a flood of sensory information. To avoid being overburdened, the visual system has evolved attention control mechanisms to focus on certain information while ignoring other information. The targets that are selected by attention can be visual features, such as specific colours, as well as specific areas of the visual field (Carrasco, 2011). In this dissertation, I will mostly focus on the latter aspect of attention – spatial attention.

Spatial attention has been compared to a spotlight (Posner et al., 1980). When the spotlight of attention remains in a certain area, the processing of information arriving from that area is enhanced while the processing of information arriving from elsewhere is diminished. I will use the term **attention allocation** to refer to both the shifting of the spotlight of attention to a certain area and the subsequent prioritized processing of this area. It is important to note the following: the spotlight of attention does not have a well-defined area (with sharp edges), there can be more than one spotlight of attention (Müller et al., 2003), and it can take other shapes rather than a circle, such as an annulus (Jefferies & Di Lollo, 2015). Nonetheless, a spotlight is a useful metaphor when attempting to understand spatial attention (Eriksen & James, 1986).

Attention allocation has been explained with endogenous, exogenous, as well as affective mechanisms (Brosch et al., 2011; MacLean et al., 2009). Endogenous attention refers to top-down influences on perception arising from factors such as goals and expectations. For example, endogenous attention is involved in following instructional rules, such as responding to the colour rather than the meaning of a presented word in a Stroop task. Exogenous attention, on the other hand, refers to bottom-up, largely unintentional influences, on perception arising from spatial or temporal discontinuities in relatively low-level visual features, such as brightness (Theeuwes, 1994).

Besides directing the spotlight of attention, attention control also involves adjusting the size of the spotlight (Goodhew, 2020). This can be referred to as adjusting the **breadth of attention** to be narrow or broad, meaning that the spotlight of attention is either small or large, respectively. The act of narrowing and broadening attention has been compared to a zoom lens (Eriksen & James, 1986). This metaphor illustrates the trade-off between the area of focus and the resolution of the focus. When a lens is zoomed-in it captures a small area with high resolution; whereas, when a lens is zoomed-out it captures a large area with lower resolution. The breadth of attention is also related to the processing priority of local elements versus its global shape in a hierarchical stimulus (Navon, 1977). Neuroimaging studies have shown that attending to the global shape, as opposed to local elements, of a hierarchal stimulus does induce brain activity consistent with the zoom lens model, and thus, this likely induces different attentional breadths (Müller et al., 2003; Sasaki et al., 2001).

Both attention control mechanisms, attention allocation and breadth of attention, can be influenced by affect. This affective influence on attention is often referred to as emotional or affective attention (Vuilleumier, 2015). Mainly this means that attention is allocated in a prioritized manner to affective stimuli. This phenomenon has been demonstrated with varied affective stimuli, like emotional faces (Hansen & Hansen, 1988) and reward cues (Pessoa, 2015). Similarly, affect can shift the breadth of attention: for instance, this has been demonstrated with emotional video clips (Fredrickson & Branigan, 2005), reward cues (Gable & Harmon-Jones, 2011), and enactments of avoidance and approach behaviours (Förster et al., 2006). However, researchers have ascribed these influences to different aspects of affect, and thus it is still unclear which aspects of affect are driving these changes.

1.2. Affective states

In order to understand how affective influences on attention control arise, we need to understand the nature of affect. This question has been mainly addressed by focusing on the nature of emotion, which has been widely discussed and disagreed upon in several works (Izard, 2010; Sander, 2013). This disagreement is evident from the number of different approaches taken to define emotions, which range from biological perspectives (emphasizing a biologically determined set of basic emotions) to social constructionist perspectives (emphasizing the social nature of affective experiences; Gross & Barrett, 2011). Although there is number of different theories about affect, there is also some common ground between the theories. The most dominant theories seem to agree that affect is not unitary but consists of multiple components (Sander, 2013). A set of five components are usually outlined: a cognitive component (appraisal), a neurophysiological component (bodily reactions), a motivational component (action tendencies), a motor-expression component (facial and vocal expressions), and a subjective feeling component (emotional experience; Scherer, 2001).

Researchers also agree that there are meaningful differences among emotions and other affective states. This variance is often described through the valence and arousal dimensions (Russell, 1980). Valence is usually characterized as a displeasure-pleasure continuum. Arousal is characterized as a deactivation-activation continuum which refers to one's alertness level. These dimensions are considered to be fundamental characteristics of affect, assumed to reflect the workings of neuropsychological systems that generate all affective states (Posner et al., 2005).

However, the exact relationship between valence and arousal is still unclear. Some authors have considered valence and arousal independent of one another (e.g., Barrett & Russell, 1999), whereas others have assumed that they are correlated (e.g., Clore et al., 1987). There are also several possible ways in which valence and arousal could be correlated. In some studies, valence has been found to be negatively or positively correlated with arousal depending on the culture in question (e.g., Tsai et al., 2006). Often, a V-shaped relationship emerges, whereby arousal has separate linear relationships with positive and negative valence; these may have similar or divergent slopes (e.g., arousal increases more strongly for negative or positive valence) as well as intercepts (e.g., the starting point on arousal scale is higher for positive valence than for negative).

To help adjudicate between these different possibilities, in a recent large collaboration study, we investigated the valence-arousal relationship on a larger scale. Yik, Russell, and colleagues (2022) collected data across six continents from 33 countries and in 25 different languages. In total, 8590 university students recalled an especially clear memory form a day before. They then rated their feelings associated with this memory on a 5-point Likert scale (from "not at all" to "extremely") in response to 16 affect adjectives which measured negative valence (e.g., "miserable"), positive valence (e.g., "happy"), high arousal (e.g., "intense"), and low arousal (e.g., "still"). We found that the relationship between valence and arousal varies remarkably between the countries. Across different countries, the data were most often explained either by a model assuming a positive linear relationship or a model assuming a V-shaped relationship with a steeper slope for positive valence. Pooling data from all the countries, we found that feeling more pleasant is accompanied by a rise in activation level, whereas feeling unpleasant has no clear relationship with activation level.

One reason why it has been difficult to identify a systematic relationship between valence and arousal may be that there is no single systematic relationship, because valence and arousal are not the indivisible essence of affect but instead are reflections of a number of different component processes of affective states. This view is consistent with the idea that emotions and other affective states may be best viewed as systems.

Systems consist of interconnected components that work together to achieve certain outcomes (Meadows, 2009). In other words, systems have three defining characteristics: individual components, connections between components, and a purpose or function that the system serves. In psychology, many models of mental constructs have characteristics of a system. For instance, the working memory model by Baddeley and Hitch (1974) has concrete components (e.g., phonological loop, visuospatial sketchpad), proposes concrete connections between the components, and the entire system has a specific function. Similarly, many emotion models have characteristics of systems, even if the different models posit slightly different components, connections, and functions. For instance, according to the basic emotion theory, different emotions involve different genetically predisposed sets of components such as specific facial expressions and physiological responses (Ekman, 1992). According to social construction theory, on the other hand, social context is also a necessary component of an emotion system (Boiger & Mesquita, 2012). The different emotion theories are in line with the system theory ideas; they include specific components which are interrelated, with the whole system having a concrete purpose.

Viewing emotions and other affective states as configurations of a system provides a useful framework for considering the origins of affective influences on attention control. In particular, the component of appraisal merits closer inspection.

1.3. Appraisals as a source of affect

The framework of **appraisal theory** of emotion posits that fundamental components of affective processes are appraisals which can be viewed as the assessment of a stimulus/event according to the current goals of the perceiver (Moors et al., 2013; Scherer, 2001, 2009a). The appraisal process is considered to be mostly fast and automatic, thus the perceiver does not need to be consciously aware of this process (Moors, 2010). One of the key tenets of appraisal theories is that the outcome of appraisals can trigger reactions in other affect components and thus elicit emotions (Moors, 2010). Appraisal theories usually assume that in most cases appraisal is a necessary starting point for the affective process, meaning that, generally, for a stimulus to elicit an affective reaction there has to be some kind of appraisal.

According to appraisal theories, the assessment of a stimulus/event involves different appraisal dimensions, which reflect how the stimulus relates to the perceiver's goals. Appraisal theories have suggested numerous appraisal dimensions which contribute to the affective process in a unique and meaningful manner (Clore & Ortony, 2008; Moors et al., 2013; Scherer, 2001). Most appraisal theories include a core set of appraisals: goal relevance, goal congruence, certainty, power, and agency appraisals (Moors et al., 2013). For example, appraising an event as goal relevant, goal incongruent, and caused by someone else can result in the feeling of anger. A small change, like appraising an event as goal relevant, goal incongruent, and caused by yourself, could instead result in the feeling of sadness. Of the five dimensions, goal relevance and congruence appraisals are often considered primary appraisals that occur in all affective events (Smith & Lazarus, 1993) and are most closely related to the two core dimensions of arousal and valence, respectively (Russell, 1980; Watson & Tellegen, 1985). The remaining appraisal dimensions can be considered secondary appraisals that help the emotion system to respond to the demands of the situation. Thus, every appraisal dimension is suggested to have a significant effect on affective experience.

In summary, appraisal can be viewed as a key component in the affective process that triggers affective reactions and changes in other affective components. Thus, it is reasonable to assume that the appraisal process also plays a role in modulating attention control.

1.4. Attention control as an appraisal-driven component of affect

Considering affect as an appraisal-driven system provides a useful framework for analysing the different ways in which affective states could influence cognitive processes, such as attention control. On the one hand, the influence affect has on cognitive processes may arise from the activity of the whole system underlying an affective state. In other words, this means that the synchronized activity of affect components is required for an effect on cognition. This state of the affect system is often thought to be reflected in the subjective experience (i.e., the feeling component) of affect which monitors and integrates the changes in other components (Scherer, 2009b). Alternatively, the cognitive impacts may stem directly from individual components of the affective system, such as appraisal.

As an example of the first approach, consider the affect-as-information (Schwarz, 2002) account which posits that affective experiences, especially the feeling that is thought to reflect the state of the affective system, adjusts cognitive processes for the current requirements by providing information about the environment. In other words, affective experiences can be viewed as affective cues which signal whether the environment is safe and benign, or not safe and possibly harmful. As such, the positive affective state signals that the environment is benign and therefore we can be more explorative and cognitively broad (i.e., rely on global processing, abstract thinking, and a broad breadth of attention). Conversely, the negative affective state signals that the environment is not safe and therefore increases the need for direct action and reliance on detail-oriented cognitive processing (i.e., with an analytical, narrow breadth of attention). The idea that cognitive changes arise from the state of the whole system has also been used in explaining affective influences on attention control (Fredrickson & Branigan, 2005; Huntsinger, 2012).

Alternatively, affective influences on cognition may arise from individual components of the affective system such as action tendency, subjective feeling, or, in particular, appraisal. Several lines of behavioural and brain research suggest that attention can indeed be influenced by components of the affective system rather than the state of the full system. Behavioural research has shown that affective shifts in attention control happen quickly and even without the conscious experience of affect. For example, studies have shown that implicit affective cues – cues that have affective meaning but are not consciously processed – influence breadth of attention, suggesting that the affective influence happens before the subjective experience of affect (Friedman & Förster, 2010). Furthermore, this early affective influence on attention is supported by contemporary brain research. For instance, although traditionally the amygdala has been connected mainly to emotional functions, such as fear detection (Öhman & Mineka, 2001), it has also been linked to appraisal processes and attentional processes. In the former case, research has shown that the amygdala's activity is linked to relevance detection which is a key part of the appraisal processes (Sander et al., 2003). In the latter case, studies have shown that signals from the amygdala can enhance the sensory processing of a stimulus by increasing its neural representations in the brain, and thus influences early attentional processes (Compton, 2003).

In this dissertation I investigated whether the appraisal component of affect can be the underlying cause of affective influences on cognitive processes. This hypothesis is in line with evidence suggesting that appraisals can orchestrate changes across many components of the affective system. For example, studies have shown that the appraisal process predicts facial muscle activity (Delplanque et al., 2009; Gentsch et al., 2015), vocal expressions (Laukka & Elfenbein, 2012), cardiovascular activity/heart rate and skin conductance (Aue & Scherer, 2008; Delplanque et al., 2009; Kreibig et al., 2010, 2012). These findings are in line with the idea that appraisal processes orchestrate changes in other components. It is therefore reasonable to assume that the appraisal process also impacts cognitive processes that are strongly related to affect, such as attention control.

1.5. The aims of the dissertation

The broader aim of this dissertation is to systematically explore the possibility that attention control is influenced directly by the appraisal process. To this end, the two studies of this thesis experimentally investigate the impacts of three appraisal dimensions on two different aspects of attention control: attention allocation and breadth of attention. This pair of focal studies were complemented by two methodologically oriented studies clarifying the relationship between pupil size and different aspects of attention control, setting the stage for future research into individual differences.

This dissertation first gives an overview of pupil size as a measure of attention control. The specific aim of **Study IV** was to examine whether pupil size reflects changes in breadth of attention. We expected to see that the broadening of attention dilates the pupil. Next, the dissertation focuses on appraisal effects on attention control. **Study I** investigated the effects of goal relevance and goal congruence appraisals on attention allocation. **Study II** examined the effects of goal congruence and power appraisal on breadth of attention. Finally, the dissertation proposes that future research examining affective effects on attention control should take into account individual differences, especially when concerned with the personality traits of extraversion and neuroticism. For this aim, future research could benefit from the usage of implicit personality measures which could provide additional information about participants' emotional reactivity. **Study III** examined whether self-report and implicit personality measures reflect the same aspects of the extraversion and neuroticism personality dimensions.

2. PUPIL DILATION AS A MEASURE OF ATTENTION CONTROL

Pupillometry has a long tradition in psychological research. The method was established as a way to measure cognitive processes in the 1960s when a seminal study by Hess & Polt (1960) showed that arousing images increase pupil size. Further research showed that not just arousing images, but also cognitive processes such as mental calculations increase pupil size (Hess & Polt, 1964; Kahneman & Beatty, 1966). In the past decades, due to the availability of easy to use and non-invasive measurement devices the usage of pupillometry in psychology research has steadily increased (for a comparison of different eye trackers see Table 3 in Gibaldi et al., 2017). The specific cognitive processes that are indexed by pupil size can be difficult to pinpoint as it may seem that almost everything that activates the mind dilates the pupil. However, within well-designed experiments, pupil size can be used to make inferences about specific cognitive processes. Next, I will give a short overview of the main difficulties with the pupil response that experiment designs need to take into account. After that, I will discuss findings relating pupil dilation to attention control. Finally, I will give an overview of an empirical study where we examined whether pupil size coincides with changes in breadth of attention.

2.1. Non-cognitive influences on pupil size

There are several non-cognitive factors that can influence pupil size. The main ones are pupillary light reflex, the near response, the lid-closure effect, and the pupil foreshortening effect. The first two factors impact the actual pupil size, whereas the other two factors impact mainly the two-dimensional image of the pupil captured by the eye tracker. These factors are usually not the main interest in psychological studies, and thus they should be controlled by using appropriate pupil pre-processing techniques, experimental design characteristics, or statistical methods. The different factors are discussed in more detail below.

In response to darkness, pupils dilate to let more light into the eye, and in response to brightness, pupils constrict to reduce the amount of light reaching the retina. The **pupillary light reflex** produces the most notable changes in pupil size, and thus, if not controlled sufficiently it can easily confound the investigation of cognitive effects on pupil size. The problem can be addressed by using simple and similar stimuli in different conditions, for instance by differentiating stimuli using colours with equal luminance.

A more nuanced confounding factor is the **pupil near response**, which refers to the impact of the focal point of the gaze on the pupil size. Pupil size decreases when focus is changed from a faraway object to a close object (Kasthurirangan & Glasser, 2005). Although this confound mostly concerns studies where stimuli are presented at different distances, it can also become a problem when stimuli presented at the same distance are perceived to lay at different distances, due to different depth cues. Generally, the near response effects are small and often do not overshadow cognitive effects on the pupil (Kooijman et al., 2020). However, researchers should be mindful of this problem when the expected cognitive effect is very small or when the stimuli in different conditions include depth cues, including differences in size. It is not always clear whether a stimulus will activate the near response. One way to find out is to monitor changes in horizontal eye positions which are part of the near response. The convergence of the eyes suggests that the gaze focuses on a nearby object and the pupil might constrict, whereas the divergence of the eyes suggest the opposite: that the gaze focuses on a faraway object and the pupils dilate. Given its correlation with gaze position, the effects of the near response on pupil size can be statistically controlled-for by entering gaze positions as nuisance variables to a generalized additive mixed model (van Rij et al., 2019).

The **lid-closure effect** refers to the partial occlusion of the pupil by the eyelid during eye blinks. Before and after the eyeblink the lid gradually covers and uncovers the pupil which is recorded by the eye tracker as a fast change in the pupil size. This problem in the recording can be eliminated by increasing the period of time encoded as an eye blink when the pupil is entirely covered by the eyelid in both directions in time.

A similar problem, an apparent change in the pupil size captured by the eye tracker, arises due to the **pupil foreshortening effect**. As a result of the oval shape of the eye, a stationary eye tracker records a decrease in the pupil size when the eye rotates. Presenting stimuli in different parts of a stimulus screen can elicit this effect in most eye trackers (Hayes & Petrov, 2016). To overcome this problem stimuli should be presented centrally, so that at crucial time points a participant's gaze does not move around the screen. In addition, statistical methods, such as generalized additive mixed models, can take into account possible differences in pupil size due to gaze position (van Rij et al., 2019).

2.2. Cognitive influences on pupil size

It is well documented that several cognitive processes can influence pupil size (Beatty & Lucero-Wagoner, 2000). For example, studies have shown that pupil size is increased by recalling different events (Kahneman & Beatty, 1966), doing mental calculations (Ahern & Beatty, 1979), paying attention (Kang et al., 2014), hearing emotional tones (Partala & Surakka, 2003), viewing emotional pictures (Aboyoun & Dabbs Jr., 1998), and receiving rewards (Chiew & Braver, 2011). The effects resulting from cognitive processes are considerably smaller and slower than the pupil light reflex, but they are still easily observable with eye trackers, yielding an objective and cost-effective measure of these processes.

Overall, two main underlying cognitive factors – arousal and mental effort – can explain many cognitive effects on pupil size (e.g., Beatty & Lucero-

Wagoner, 2000; Laeng et al., 2012; Mathot, 2018; van der Wel & van Steenbergen, 2018). Arousal is implicated in controlling the pupil by findings that states of high autonomic arousal as well as emotionally arousing stimuli dilate the pupil (Bradley et al., 2008; Partala & Surakka, 2003). Mental effort is implicated in controlling the pupil by findings that task difficulty and the cognitive effort recruited by the task dilate the pupil (van der Wel & van Steenbergen, 2018). Considering these two factors, it seems that pupil size reflects the intensity of cognitive processes; that is, it reflects how intensely the cognitive system operates and the load it puts on the attentional capacity (Just & Carpenter, 1993; Kahneman, 1973).

Besides the mentioned factors, it has been also explicitly suggested that pupil dilation reflects attentional processes. This idea is supported by conceptual arguments, and behavioural and neurophysiological studies. First, on a conceptual level, although varied psychological constructs dilate the pupil, many of them are connected to attentional processes. Research has shown that pupils dilate in response to cognitive processes that arguably require selective attention. For example, selective attention plays an integral part in processes such as working memory (Kahneman & Beatty, 1966), mental calculations (Ahern & Beatty, 1979), and attentional effort (Kang et al., 2014). Second, there is also direct evidence linking pupil dynamics to perceptual selection (Einhäuser et al., 2008) and attentional constructs such as alerting, orienting, and executive monitoring (Geva et al., 2013). Third, pupil size reflects the activity of brain region called locus coeruleus (LC) which takes part in regulating selective attention (Aston-Jones & Cohen, 2005). The LC is a set of nuclei in the brainstem that has noradrenergic projections to the whole brain, and thus is also called the locus norepinephrine system (LC-NE; Samuels & Szabadi, 2008). Early theories emphasized more broad effects of LC activity on the organism, such as regulating arousal states and the sleep-wakefulness cycle (for a review see Sara, 2009). Recent findings suggest, however, that the LC-NE system has also more nuanced functions in regulating behaviour. Notably the LC-NE system has been linked to selective attention processing because it has dense projections to brain areas involved in attentional processing (parietal cortex, pulvinar nucleus, superior colliculus; (Foote & Morrison, 1987). Thus, some authors have proposed that the LC system is involved in integrating different attentional systems in the brain (Corbetta et al., 2008; Sara, 2009). Importantly, studies have shown that pupil size has a high correlation with LC-NE activity. For example, single cell studies have shown that there is a high correlation between the two signals in monkeys (Joshi et al., 2016), mice (Liu et al., 2017) and humans (Murphy et al., 2014).

Given that pupil size reflects attentional processes, it can give a unique online measure of these processes during visual attention tasks. Using pupil size to investigate attention can provide unique information about the unfolding of attention over time. Neurophysiological studies have shown that attention modulates brain areas in a dynamic manner by gradually increasing the activity in different areas (Martínez et al., 2001). Thus, online measures that capture attention dynamics as they unfold can give valuable information about attention allocation. For this aim, researchers have utilized the fact that pupil dilation reflects attentional load capacity (Geva et al., 2013; Naber et al., 2013). This can be especially useful for examining how much attention is allocated to a specific stimulus. The initial pupil response can give information about whether the stimulus captures attention, whereas the ongoing pupil response can give information about further attention allocation to the stimulus.

Using pupil dynamics to investigate attention requires one to understand which aspects of attention control are reflected in pupil dynamics. It is relatively clear that pupil size can be sensitive to the allocation of visual attention (Geva et al., 2013; Naber et al., 2013). However, it is less clear whether pupil size can also reflect breadth of attention.

2.3. Pupil size reflects breadth of attention

There are several reasons to expect pupil size to covary with the breadth of attention. First, both pupil dilation and broader attention have similar impacts on the trade-off between acuity and sensitivity in early visual processing. Dilation of the pupil blurs the retinal image and increases overall visual sensitivity; whereas, constriction of the pupil sharpens the retinal image (thus decreasing visual sensitivity) but increases visual acuity (Mathôt & Van der Stigchel, 2015). For instance, pupil dilation in darkness increases overall visual sensitivity (i.e., the detection of faint stimuli); pupil constriction due to brightness, on the other hand, increases visual acuity (i.e., the detection of fine details); likewise, looking at a faraway object reduces pupil size and increases the depth of field (i.e., the range where the object is still in focus). Similar to pupil size, breadth of attention has been linked to early visual processing. Broad breadth of attention increases the overall area under focus at the expense of visual acuity (Eriksen & James, 1986; Lawrence et al., 2020). Conversely, narrow breadth of attention decreases the focused area but increases the visual acuity of the small attended areas (Balz & Hock, 1997). In conclusion, considering their similar impact on visual processing, it is possible that smaller pupil size co-occurs with narrow breadth of attention and that larger pupil size co-occurs with broader breadth of attention.

Furthermore, the idea that pupil size might coincide with breadth of attention is also suggested by their shared associations with the LC-NE system. According to the adaptive gain account of the LC-NE system (Aston-Jones & Cohen, 2005), its activity regulates the trade-off between two types of behavioural tendencies – exploration and exploitation. Exploration mode is characterized by constant LC activity (i.e., tonic activity) and it is associated with behaviour resulting from low task utility, task disengagement, and looking for new opportunities. Exploitation mode is characterized by short bursts of high frequency LC activity (i.e., phasic activity) and it is associated with behaviour resulting from high task utility, task engagement, and optimizing task performance. It is possible that breadth of attention is modulated by the LC-NE system in the service of exploration and exploitation of environmental opportunities (Aston-Jones & Cohen, 2005; P. Gable & Harmon-Jones, 2010b). Narrow breadth of attention helps to focus one's cognitive resources on the current goal and, thus, facilitates task engagement, which is a hallmark of exploitation behaviour. In a similar manner, broad breadth of attention helps one to disengage from the current goal and look for new opportunities, thus facilitating exploratory behaviour. Similarly, pupil size is proposed to reflect the shift between the explorative and exploitative modes of goal pursuit (Aston-Jones & Cohen, 2005). Thus, as both breadth of attention and pupil size are modulated by LC activity, it can be hypothesized that pupil size reflects the changes in breadth of attention.

Finally, several empirical studies provide preliminary evidence that the pupil is more dilated when the breadth of attention is broad compared to narrow (Brocher et al., 2018; Daniels et al., 2012; DiCriscio et al., 2018; Eldar et al., 2016; Mathôt & Ivanov, 2019). For example, Daniels et al. (2012) asked participants to focus their attention between centrally presented stimuli and peripherally presented stimuli. They showed that pupils were larger when participants had to focus on the peripherally presented stimuli. Additionally, there is evidence that pupil response is smaller during the selection of local information relative to global information. DiCriscio et al. (2018) showed with Navon stimuli (e.g., large letters made out of small letters, as in a large "P" made out of small "H-s") that pupils dilated more when participants focused on the global shape of letters compared to focusing on the small letters which composed them. In addition, Mathôt and Ivanov (2019) showed that manipulating pupil size improves vision for specific tasks. They manipulated pupil size by using different light conditions and a detection and discrimination task (which benefit from better visual sensitivity and acuity, respectively). They showed that small pupils were beneficial in tasks that require visual acuity, while large pupils were beneficial in tasks that require visual sensitivity (i.e., detecting of faint stimuli).

However, these preliminary findings await replication, and some of their crucial limitations need to be addressed. Firstly, some of the existing findings may have been confounded by the effects of mental effort. Pupils may dilate more for peripherally presented, as compared with centrally presented, stimuli (Daniels et al., 2012), because attending to peripheral stimuli requires more mental effort (Brocher et al., 2018). Secondly, past findings may have been somewhat confounded by the pupil near response. Although the effects of the near response are generally small (Kooijman et al., 2020), it can confound the results in breadth of attention studies when narrow and broad breadth-of-attention conditions use stimuli with different sizes. The aim of Study IV was to replicate the association between breadth of attention and pupil size using a novel paradigm that addresses these limitations.

STUDY IV: Broader attention correlates with dilated pupil

In Study IV, we investigated the relationship between breadth of attention and pupil size. For this aim, we designed a novel experimental paradigm that combines a shape discrimination task (circle task) as an attentional breadth induction procedure (Goodhew et al., 2016) and a visual search task (ellipse task) as a manipulation check. More specifically, the former task is used to induce either broad or narrow breadth of attention, and the latter is used to test whether the manipulation of breadth of attention was successful. In the circle task, participants were asked to detect whether a gap in a Landolt circle was pointing upward or downward (Kliegl et al., 2014). Two different sized Landolt circles were presented simultaneously on the screen. To induce narrow breadth of attention, participants were instructed with a pre-stimulus cue (an auditory tone) to detect the gap in the smaller circle (radius of 0.7 deg); whereas, to induce broad breadth of attention, participants were instructed (with a slightly different pre-stimulus auditory tone) to detect the gap in the larger circle (radius of 7 deg). Directly after the circle task, in the ellipse task, participants were asked to detect whether a tilted ellipse among seven upright distractor ellipses was tilted towards the right or the left. The distance of target ellipses from the centre of the screen was manipulated to assess the breadth of attention effect (at 1, 2.5, and 6 deg from centre of the screen). We expected that a successful manipulation of breadth of attention should result in a better detection of target ellipses further away from the centre of the screen (target ellipse at 6 deg from centre of the screen) for the broad compared to the narrow breadth-of-attention condition. If pupil size indeed coincides with breadth of attention manipulation, we should see larger a pupil size in the broad compared to the narrow breadth-of-attention condition. In total, 24 participants completed the experiment which consisted of 384 trials and contained 64 repetitions for each condition.

We first asked if the circle task manipulation was successful. We relied on a computational approach called drift diffusion modelling (DDM; Ratcliff, 1978) to identify a robust correlate of perceptual decision process that is unconfounded by different solutions to the speed-accuracy trade-off that participants can adopt across different conditions (Voss et al., 2013). According to DDM, in a two-choice decision task, a decision is reached when enough perceptual evidence is accumulated for one of the two response options (Ratcliff & McKoon, 2008). The model uses both reaction times and error rates to extract a number of latent decision-making parameters including the drift rate parameter that describes the rate of evidence accumulation and thus should be connected to perceptual processing efficiency (Lerche et al., 2017; Schmiedek et al., 2007). Using the drift rate as a dependent variable, we found that our manipulation of breadth of attention was partially successful. In the broad breadth of attention condition, the decrease in the drift rate parameter with increasing target ellipse distance was less pronounced than in the narrow breadth of attention condition. In other words, when the target ellipse was presented further away from the centre of the screen, evidence accumulation was more effective in the broad, compared to the narrow breadth-of-attention, condition. This result is in line with the idea that narrow breadth of attention should enhance the detection of central stimuli, whereas broad breadth of attention should enhance the detection of peripheral stimuli.

In the main analysis we compared pupil dilation between the narrow and broad breadth of attention conditions. We expected to see a larger pupil size in the broad breadth of attention condition. To test this hypothesis, while statistically controlling for **pupil near response**, we used generalized additive mixed models. These models allowed us to analyse dynamic changes in the pupil size throughout the trial, while controlling for the pupil near response by including the divergence value of left and right horizontal eye positions in the model. The results showed that pupil size indeed was larger in the broad breadth of attention condition. Importantly we showed that this difference is already apparent during the circle task used to induce breadth of attention. Thus, the results aligned with previous evidence for a relationship between pupil size and breadth of attention. In addition, we controlled for the possible confounding effect of the pupil near response.

We also sought to address the **mental effort problem** by presenting all stimuli centrally (radius of 7 deg), as detecting stimuli in one's peripheral vision requires more mental effort (Brocher et al., 2018). In addition, at the end of each trial we asked participants to recall the gap location in the circle, either in a small or large circle depending on the breadth of attention condition. We assumed that a lower accuracy indicates a higher task difficulty, and thus, a higher requirement for mental effort. The analysis showed that participants made more mistakes in the narrow breadth of attention condition. Thus, it suggests that the two conditions were not equal in mental effort. However, the difference in the error rates was rather small and it worked against our main effect by likely increasing pupil size in the narrow breadth of attention condition (i.e., it is not a true confound).

We also asked whether the breadth of attention effect on visual performance was mediated by pupil size. As such, using a mediation analysis, we found that the behavioural effects of breadth of attention were not mediated by pupil size. Thus, although there are studies suggesting that pupil size directly tunes visual attention (Mathot, 2018; Mathôt & Ivanov, 2019; Mathôt & Van der Stigchel, 2015), our study did not support this idea. Instead, it is possible that both pupil size and breadth of attention are influenced by the same variable, and their own association is purely correlational. More research is needed to fully address this question.

In conclusion, Study IV demonstrates that the broadening of attention dilates the pupil slightly more than does the narrowing of attention. Taken together with previous findings, this suggests that pupil size can reflect attentional processes, both in terms of attention allocation as well as breadth of attention. However, the breadth of attention effect on pupil size found in this study was rather small, and pupil size did not mediate the breadth of attention effect on visual performance. Thus, further studies are necessary to determine the exact nature of this relationship.

3. APPRAISAL AS A DRIVER OF ATTENTION ALLOCATION

In this section, I will shift the discussion from the usage a pupil dilation as a measure of attention to affective influences on attention control. The aim of this section is to show that appraisal framework is a useful tool for investigating the attention allocation aspect of attention control. First, I will give a brief overview of some influential texts on this topic. After that, I will give an overview of studies emphasizing appraisal effects on attention allocation. Finally, our own study will investigate the independent effects of two appraisal dimensions on attention allocation.

3.1. Influential explanations of affective attention

It is well-documented that affect influences attention allocation. The preferential processing of affective information/stimuli has been called affective attention (Vuilleumier, 2015; Yiend, 2010). Previous research has shown that attention is preferentially allocated to stimuli with evolutionary relevance (Öhman & Mineka, 2001), to stimuli that elicit negative (Carretié et al., 2001) or positive (Buodo et al., 2002; Raymond & O'Brien, 2009) affect states, or to stimuli that elicit affective arousal (Hajcak et al., 2010). However, it is still unclear which aspects of an affective stimulus (or one's response to it) underlie the extent of attention allocation to a specific stimulus.

One influential approach to affective attention posits that the key factor is the evolutionary threat value of the stimulus (Öhman, 2009; Öhman et al., 2001; Öhman & Mineka, 2001). This approach is usually referred to as the threat superiority theory of affective attention. In short, this view argues that the attention system prioritizes the processing of stimuli that were relevant in the course of human evolution, especially threatening stimuli, such as snakes, spiders, and angry faces. This account can explain numerous behavioural and neuroimaging findings (for a review see Maratos & Pessoa, 2019). For example, fear-relevant pictures (snakes or spiders) can capture attention as well as inhibit the detection of fear-irrelevant pictures in the same array (Öhman et al., 2001; Xiaojun et al., 2018). Likewise, angry faces tend to be detected faster among happy faces than the other way around, suggesting that the threatening nature of angry faces leads to prioritized processing (Hansen & Hansen, 1988). Neuroimaging studies have revealed that threatening stimuli enhance activity in the amygdala rapidly after the stimulus onset leading to enhanced cortical processing of these stimuli (for a review see Pourtois et al., 2013).

However, evolutionary threat may not be the main mechanism behind affective attention. Instead, humans may exhibit a more general negativity bias whereby all negative stimuli are processed in a prioritized manner (Carretié et al., 2001; Pratto & John, 1991; Rozin & Royzman, 2001). From this perspective, evolutionarily threatening stimuli are processed in a prioritized manner not because of their evolutionarily threatening history but instead because of their high negative valence. This would explain why pictures of a snake and a gun capture attention in similar manner (Fox et al., 2007; Schimmack & Derryberry, 2005). Although only one of them has an evolutionarily threatening history, they both tend to be assessed as highly negative. Furthermore, studies have shown a general negativity bias, whereby negative stimuli and events tend to have a stronger impact on many aspects of behaviour than do positive ones (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001). Relatedly, prospect theory proposes that losses are more motivationally significant than comparable gains (Kahneman & Tversky, 1979). Relative to the same amount of gains, losses have indeed been found to increase heart rate (Andreas Löw et al., 2008; Hochman & Yechiam, 2011), electrodermal skin response (Andreas Löw et al., 2008; Peter Sokol-Hessner et al., 2009), and pupil dilation (Hochman & Yechiam, 2011; Satterthwaite et al., 2007).

Yet again, negative valence might also not be the ultimate source of affective attention. It is possible that various negativity-bias effects stem from different arousal values attributed to negative, as opposed to positive, stimuli (Mather & Sutherland, 2011; Padmala et al., 2018; Schimmack & Derryberry, 2005; Singh & Sunny, 2017). For instance, negative stimuli such as pictures of snakes and guns may capture attention due to their similar arousal value rather than their similar negative valence. The general negativity bias could be explained by the fact that negative and threatening stimuli are overall more arousing than neutral or positive stimuli (Bradley et al., 2001; Lang et al., 1993). Indeed, there are studies demonstrating that the arousal value of the stimulus influences attention regardless of its valence (Schimmack & Derryberry, 2005; Singh & Sunny, 2017). For example, studies have shown that sufficiently arousing positive stimuli such as erotica, food, and smiling faces are prioritized by attentional system (Pool et al., 2014, 2016). In some cases, attention is primarily allocated to positive rather than negative events (Anderson, 2005; Buodo et al., 2002; Gupta et al., 2016; Raymond & O'Brien, 2009). Furthermore, neuroimaging studies have shown that the activity of the amygdala is associated with stimulus arousal rather than its threat or valence values (Lin et al., 2020). As the amygdala is involved in the early stages of information processing (Compton, 2003), this suggests that the effect of arousal on the attentional process is not just an after-effect of other affective processes, but could also play a role in the encoding of the stimulus.

Of the different accounts that explain affective attention through the emphasis of evolutionary advantages of threat prioritization, negativity bias, and the role of arousal, the latter seems to offer the most flexible explanation consistent with most available findings. However, it may also be considered overly flexible, as arousal is a broad and often unspecified construct that can refer to different types of biological as well as psychological states. For instance, Satpute et. al. (2018) differentiate between three anatomically overlapping but functionally different types of arousal: wakeful arousal, autonomic arousal, and affective arousal. In the next section, I will give an overview of an alternative account which focuses on the appraisal process.

3.2. The appraisal explanation

Previous accounts mostly emphasize the valence and arousal values of a stimulus driving affective effects on attention allocation. Both valence and arousal can be considered as describing the activity of the feeling component of affect or the activity of the whole affective system. As the feeling component has also been thought to reflect the activity of the whole affective system (Scherer, 2009b), in both cases previous accounts seem to support the view that the whole affective system plays a role in influencing attention allocation. As a promising alternative, it is possible that affective influence on attention allocation is driven only by one affect component – by the appraisal component.

In line with this proposal, recent research has posited that the subjective relevance of a stimulus drives attention allocation. More precisely, it has been argued that the perceiver's current goals and the subjective relevance of the stimulus for these goals determine attention allocation to a stimulus (Maratos & Pessoa, 2019). This relevance detection has been described as fast and automatic, meaning that the brain automatically evaluates stimuli in accordance to current goals (Maratos & Pessoa, 2019). This idea is central to many appraisal theories, which posit that relevance appraisal is the first appraisal that determines which stimulus requires further processing (Scherer, 2009b).

The benefit of this approach is that it is in line with previous research, but at the same time avoids the definitional lack of clarity of the arousal account. It also helps to explain some inconsistencies in previous findings. For example, the prioritized processing of threat stimuli could be explained by the fact that threat stimuli are usually the most relevant stimuli in the environment. Thus, not threat per se, but the relevance of the stimulus drives the processing of the stimulus. This could explain why research shows that modern threats can have the same effect on attention capture as evolutionary threats (Subra et al., 2018; Young et al., 2012). Similarly, negative stimuli may usually be assessed as more relevant than positive stimuli.

One interesting question raised by relating affective attention to appraisals is whether other appraisal dimensions, besides goal relevance, also have an additional impact on attention allocation. Although previous results suggest that relevance appraisal has the main impact on attention allocation (Maratos & Pessoa, 2019), it is still possible that other appraisal dimensions impact attention simultaneously. For instance, the negativity-bias effects leave open the question of whether the appraisals underlying the construal of a stimulus (as negative or positive) influences one's attention allocation. Therefore, one of the main candidates for additional impactful appraisal dimensions is the goal congruence appraisal, which refers to whether the stimulus or event is enabling or blocking the current goal; that is, whether it is goal congruent or goal incongruent (Moors, 2009; Scherer, 2001; Scherer, 2009). Appraising a stimulus as goal congruent could contribute to the formation of positivity bias (Buodo et al., 2002; Raymond & O'Brien, 2009), whereas appraising a stimulus as goal incongruent could contribute to the formation of negativity bias (Carretié et al., 2001; Öhman & Mineka, 2001; Yiend, 2010). Using the appraisal framework could provide a useful tool to disentangle the effects of relevance and goal congruence appraisal on attention allocation.

STUDY I: Goal-relevance appraisal drives attention allocation

The broader aim of Study I was to test the effectiveness of appraisal framework to understand the origins of affective shifts in attention allocation. Its more specific aim was to learn if goal congruence appraisal contributes to attention capture over and above goal relevance appraisal.

To measure attention allocation in a dynamic manner, we used pupil dilation as an index of preferential processing of a single stimulus. To manipulate appraisal dimensions, we used a modified monetary incentive delay task (Knutson et al., 2000). In this task, participants played a simple game to increase the amount of chocolate they obtained at the end of the experiment. Each trial consisted of an anticipation phase and an outcome phase. In the anticipation phase, participants were informed as to whether in the current trial they have the possibility to win or lose chocolate. In the outcome phase, they were informed whether the possible event happened or not. To reduce potential confounds for pupil dilation measurement, such as different brightness levels, the different events in the experiment trial were associated with simple Landolt circles (Kliegl et al., 2014). In the anticipation phase, a circle with a gap pointing downwards or upwards indicated a potential to either win or lose chocolate, counterbalanced between participants. For example, for some participants, a circle with a gap at 0 deg indicated a trial where they can win chocolate, whereas a gap at 180 deg indicated a trial where they can lose chocolate. A full circle indicated neutral trials with no change in the chocolate score. In the outcome phase, the gap directions were shifted 45 deg relative to the gap's location in the anticipation phase, to indicate whether the event happened or not. For example, when a circle with a gap at 0 deg indicated a trial with the potential to win, the outcome phase stimuli had gaps at 45 and 315 deg. Throughout the trial, verbal cues associated with the stimuli were presented before and after the anticipation and outcome phases, respectively.

In total 47 participants completed the experiment, of whom 42 were in the final sample, after the pre-processing of the data. The experiment consisted of 80 trials with 5 unique trial types, which consisted of the outcome and anticipation phases of the experiment: 1) *you may lose –> you lost*, 2) *you may lose –> you did not lose*, 3) *you may win –> you won*, 4) *you may win –> you did not win*, 5) *nothing happens –> nothing happened*.

To assess all possible goal relevance and goal congruence effects on attention allocation, we designed different definitions for the appraisals based on the different experiment conditions. We used two definitions of goal relevance. First, we assumed that stimuli with no impact on the chocolate score have low relevance (anticipation phase: *nothing happens*; outcome phase: *nothing happened*) and stimuli with an impact on the chocolate score have high relevance (anticipant phase: *you may win*, *you may lose*; outcome phase: *you did not win*, *you won*, *you did not lose*, *you lost*). Second, we assumed that stimuli denoting no actual change in the chocolate score have low relevance (*you did not win*, *you did not lose*) and stimuli denoting change in the score have high relevance (*you won*, *you lost*). We expected that if goal relevance has an effect on attention then the pupil size would be larger for high goal relevance definitions, compared to the definitions of low goal relevance. To assess the effect of goal congruence on attention allocation, we used three definitions of goal congruence. First, we assumed that the anticipation to win chocolate is construed as congruent (*you may win*) and the anticipation to lose is construed as incongruent (*you may lose*). Second, according to the relative value of the outcome of the trial, congruence was defined through the best possible outcomes (*you won*, *you did not lose*) and incongruence through the worst possible outcomes (*you lost*, *you did not win*). Third, according to the nominal value of the stimulus, we defined congruence through the positive outcome (*you won*), incongruence through the negative outcome (*you lost*), and a natural condition through outcomes having no real nominal value (*you did not win*, *you did not lose*). We expected that if goal congruence has an additional effect on attention then there would be a significant difference in pupil size in at least one of the definitions for goal congruence (with either a larger pupil dilation for the congruent or incongruent part of the appraisal definition).

To analyse the effects, we used pupil data recorded during the presentation of the respective stimuli in the anticipation and outcome phases of the trial. The main finding of Study I showed that goal relevance appraisal drives attention allocation measured through pupil dilation. To see whether goal relevance appraisal influences attention allocation, we analysed pupil dilation according to the two definitions of goal relevance. First, the results showed that stimuli denoting a potential change to the chocolate score dilate the pupil more, compared to stimuli denoting no potential change to the chocolate score, and that this was true for both the stimuli of the anticipation and outcome phases. Second, the results showed that stimuli indicating an actual change in the chocolate score dilate the pupil more than stimuli indicating no actual change to the score (i.e., the win or loss did not happen). This finding is in line with research implicating subjective relevance as one of the drivers of attention allocation (e.g., Schimmack & Derryberry, 2005). In addition, this finding adds further support for the validity of appraisal theories, like Scherer's CPM (2009a), which posits that goal relevance appraisal guides attention deployment.

In addition, we analysed whether goal congruence appraisal has any additional effects on attention allocation over and above goal relevance. We observed no goal congruence effects on attention allocation for any of the three definitions. First, the anticipation of wins and losses showed no difference in pupil dilation. Second, the relative value of the trial outcome (i.e., the most positive result vs the worst result) showed similar pupil dilation. Third, the nominal value of the trial outcome also showed no difference in pupil dilation. Thus, the results did not support the idea that goal congruence contributes to attention allocation. However, this result supports the idea that valence effects, such as positivity and negativity bias, might stem from different underlying relevance values.

In conclusion, Study I shows that appraisal framework is a useful tool to investigate how affect influences attention allocation. In addition, it illustrates the usefulness of pupillometry as a measure of attention allocation to a single stimulus. The main findings of the study support the current dissertation's proposal that attention allocation is driven by the appraisal process, and mainly by the goal relevance appraisal.

4. APPRAISAL AS A DRIVER OF BREADTH OF ATTENTION

In this section, I extend the argument that appraisals influence attention control from the allocation aspect to the breadth aspect of attention. First, I will give an overview of different influential approaches that have addressed the relationship between affect and breadth of attention. Then, I will give an overview of why appraisals should be considered as a key component in this dynamic. Finally, I will give an overview of our study, where we tested the effects of two appraisal dimensions on breadth of attention.

4.1. Influential explanations of affective influences on breadth of attention

Previous research has demonstrated that affective states can narrow or broaden breadth of attention. The relationship between affect and breadth of attention has been explained by different aspects of affect, such as arousal (Easterbrook, 1959) valence (Fredrickson, 2004), and motivational intensity (Gable & Harmon-Jones, 2010b). However, it is still not entirely clear what it is in affect that drives the changes in breadth of attention.

Initially, affective effects in breadth of attention were attributed to the arousal and valence dimensions of the affective state. Easterbrook's classical studies demonstrated that high affective arousal narrows breadth of attention (Easterbrook, 1959). Subsequent accounts have argued that negative valence has an additional narrowing effect on breadth of attention. According to an influential broaden-and-build theory (Fredrickson, 2004), affective experiences influence the overall thought-action repertoire, such that a positive mood makes it broader, while a negative mood narrows it. Similar to the affect-as-information account, it is assumed that a positive mood, by signalling a safe environment, should encourage one to be cognitively broad, and thus also broaden the breadth of attention. A negative mood, conversely, by signalling an unsafe environment, encourages one to use a focused and narrowed processing style, therefore narrowing the breadth of attention. These ideas are supported by findings that the valence of affective states impacts cognitive processing styles, as well as overall cognitive flexibility (Isen, 2002). For example, one study showed that participants in a happy mood used more inclusive categorization by including low-prototypic words into specific categories ("feet" and "camel" to the category "vehicle"), compared to participants in a neutral mood (Isen & Daubman, 1984). Yet, more relevant for the current dissertation, positive and negative affect have also been found to influence visual processing, including breadth of attention (Fredrickson, 2004). For example, positive emotions can enhance the holistic processing style of faces, whereas negative emotions can decrease it (Curby et al., 2012). A similar pattern has also been demonstrated with simple geometric shapes which measure the global-local processing style

(Fredrickson & Branigan, 2005; Gasper & Clore, 2002). Participants in a happy mood tended to process such shapes in a global manner, focusing on the global shape. Participants in a negative mood tended to focus more on the local details of the shape, thought to reflect a narrow breadth of attention.

An alternative account of the cognitive consequences of valence argues that the valence dimension of the affective experience has a more dynamic role in modulating cognition, including breadth of attention. According to the cognitive malleability account (Isbell et al., 2013) the affective states may not directly influence cognitive and attentional breadth, but instead they provide feedback about the appropriateness of the current processing style. Thus, regardless of whether the current processing style is narrow or wide, a positive affect signals that the current style is suitable for the situation, whereas a negative affect signals that the current style is not appropriate, and it should be changed. Results in line with this hypotheses have been found for different cognitive processes such as stereotyping (Hunsinger et al., 2012) and attentional breadth (Huntsinger et al., 2010). For example, after priming local attention, primed participants in a positive mood tended to exhibit local bias in the subsequent task (Huntsinger et al., 2010). However, empirical support for this view is rather limited.

An influential alternative explanation for affective effects on breadth of attention argues that instead of valence or arousal, the origins of the effects lie in motivational intensity of the affective state (Gable & Harmon-Jones, 2010). Specifically, depending on the motivational intensity, both negative and positive affective states can either broaden or narrow breadth of attention. The motivational intensity is defined as the strength of motivation to act, and it thus could be considered as part of the action tendency component of affective states. It is proposed that emotions with low motivational intensity (e.g., sadness, contentment) can broaden the breadth of attention, whereas high motivational intensity emotions (e.g., anger, joy) can narrow it. There are several studies supporting this account. For example, one study showed that pleasing pictures with high motivational intensity, such as pictures of a desert, can indeed narrow the breadth of attention (Gable & Harmon-Jones, 2008). Another study demonstrated that negative pictures with low motivational intensity (pictures of sad events) can alternately broaden the breadth of attention, but specifically with negative pictures with high motivational intensity (pictures of disgusting events) narrowing it (Gable & Harmon-Jones, 2010a).

In summary, there have been different (and promising) accounts which have attempted to explain affective influences on the breadth of attention. Of those previously mentioned, the motivational intensity account seems to offer the most flexible explanation, and it is able to explain most of the available findings. However, it is still possible that it does not explain the core nature of affective effects on the breadth of attention. Another overlooked aspect that could drive these effects is the appraisal component of affect. As the appraisal process has been shown to influence attention allocation, it is reasonable to assume that it could also have an effect on the breadth of attention. In addition, there are findings which are not entirely consistent with the motivational intensity account, which implicate other affective aspects, such as appraisals, as the drivers of affective effects on the breadth of attention (Friedman & Forster, 2011; Friedman & Förster, 2010). This will be the focus of the next section of this dissertation.

4.2. Appraisal as a possible influence on breadth of attention

The previously mentioned accounts could be viewed as suggesting that the changes are driven by either the whole affective system underlying an affective state or a specific affect component, other than appraisal. The arousal and valence effects are more in line with the former account, as both dimensions accompany the general subjective affective experience, thought to reflect the activity of the whole affective system (Scherer, 2009b). The motivational intensity account, on the other hand, suggests that the action tendency component of affect directly influences breadth of attention. We propose that the affective effects in breadth of attention happen earlier in the affective processes, at the appraisal level.

Some previous research could be interpreted as providing support for the idea that appraisals influence breadth of attention. Research has shown that the goal status (i.e., whether a current goal is achieved or not) can shift breadth of attention (Kaplan et al., 2012). For example, in a gambling-like task (Gable & Harmon-Jones, 2011), participants' attentional breadth was measured during the anticipation (pre-goal) of a positive or negative event and after receiving the outcome (post-goal). The results showed that pre-goal, anticipating the event narrowed the breadth of attention regardless whether the anticipated event was a win or a loss. The same was true for the post-goal emotions: it broadened breadth of attention regardless of the nature of the trial, a win or a loss. This idea fits together with the motivational intensity account, as pre-goal affective states can be considered higher in motivational intensity, and post-goal affective states should have lower motivational intensity. However, goal status is not a property of action tendency but rather the property of an appraisal of the situation, as it reflects a motivationally relevant feature of a situation. This suggests that the origins of affective narrowing and broadening of attention may lie within the appraisal component.

Other research has shown that shifts in breadth of attention do not necessarily require conscious affective experience (Friedman & Förster, 2010; Hengstler et al., 2014) which is consistent with the idea that appraisals can be automatic and partially unconscious (Moors, 2013). For example, in one study, participants completed a virtual maze by leading a mouse to a piece of cheese or by helping a mouse to escape from an owl (Förster et al., 2006). Even as feelings reported by participants did not differ between the conditions, completing the first maze broadened breadth of attention, while completing the second maze narrowed it (Friedman & Förster, 2010; Hengstler et al., 2014). This suggests that breadth of attention can be influenced by implicit affective cues, such as approaching a reward or escaping a threat. Implicit affective cues convey important motivational information about the situation, such as its goal conduciveness, even if they do not elicit a conscious emotional experience. This is consistent with the appraisal approach, as the effect of implicit affective cues can come from automatic appraisals.

In summary, even as researchers have not always articulated it, several existing findings are consistent with the idea that affective shifts in breadth of attention are driven by emotion-antecedent appraisal processes. We test this assumptions in Study II.

STUDY II: Goal congruence and power appraisal show no effect on breadth of attention

The aim of Study II was to examine whether appraisals have an effect on breadth of attention. As with attention allocation, we hypothesised that shifts in breadth of attention are driven by the appraisal process. We focused on two appraisal dimensions (goal congruence and power appraisal), which should underly the previously proposed effects of valence and motivational intensity on breadth of attention, respectively. As goal congruence appraisal has been associated with the valence dimension of the affective experience (Frijda et al., 1989), we assumed that it should underly the effects of valence on breadth of attention. More concretely, we hypothesised that goal congruent events, likely eliciting positive emotions, should broaden breadth of attention, whereas goal incongruent events, likely eliciting negative emotions, should narrow breadth of attention. We also examined the effects of power appraisal, which can be defined as an assessment of one's resources to change the contingencies and outcomes of a task, in accordance with a current goal (Scherer, 2009b). Situations that are relatively easy to change are appraised as high in power, whereas situations that are difficult or impossible to change are appraised as low in power. As power appraisal can be associated with the motivation to act, we assumed that it underlies the effects of the motivational intensity on breadth of attention. Thus, high-power appraisal, likely leading to high motivational intensity, should narrow breadth of attention because attention is focused on the aspects of the situation that enable a person to change it. Low-power appraisal, on the other hand, should broaden breadth of attention because attention is used to explore new ways to increase one's control over the situation.

Study II consisted of two separate web-based experiments. The experiments used the same appraisal manipulation but different breadth of attention measures. In **Experiment 1**, 236 participants completed the experiment, of whom 209 were included in the final sample, after pre-processing of the data. To manipulate the appraisal dimensions, we used a game-like task, adopted from Gentsch et al. (2013), where participants played an arithmetic game to obtain victory points (see article method sections for more details). To obtain a high score, they had to solve simple arithmetic problems at the end of each trial. Goal congruence appraisal was manipulated by the potential impact of the current trial on the overall score. It was possible to lose points on half of the trials and win points on the other half. Power appraisal was manipulated by the potential to change the outcome of the current trial. On half the trials, participants were able to respond to the arithmetic task, and thus they had control over the outcome of the trial. On the other half, the responses in the arithmetic task were made by a "robot", and thus this conveyed a low-power situation.

The dependent variable measure (the flanker task) was embedded within the arithmetic task. In the flanker task, five arrows were presented on the screen, a middle arrow flanked by four response-compatible or response-incompatible arrows (Eriksen & Eriksen, 1974). Participants were instructed to respond to the middle arrow. Breadth of attention in the flanker task is indicated by the difference between response-compatible and response-incompatible trials. A larger difference indicates a broad breadth of attention, as the flanking arrows interfere more with the processing of the central arrow in response-incompatible trials. A smaller difference shows less interference by the flanking arrows in the processing of the central arrow, and it thus indicates a narrow breadth of attention.

In total, the experiments consisted of 128 trials with 8 unique trial types, which consisted of four appraisal combinations for two dependant variable levels (flanker: response compatible vs response incompatible). The appraisal combinations were as follows: 1) *you can win points* (goal congruent) – *you control the outcome of the trial* (high-power) 2) *you can win points – you do not control the outcome of the trial* (low-power), 3) *you can lose points* (goal incongruent) – *you control the outcome*, 4) *you can lose points – you do not control the outcome*.

To analyse the data we used a classical approach (reaction time and error rate analysis) and DDM analysis focusing on the drift rate parameter (described in more detail under Study IV). We expected that breadth of attention is narrower in goal incongruent and high-power trials resulting in a) faster reaction times, b) fewer errors, and c) higher drift rates for response-incompatible flanker trials (rather than response-compatible trials). The analysis did not show any of the expected effects. We also expected that breadth of attention is broader in goal congruent and low-power trials resulting in a) faster reaction times, b) fewer errors, and 3) a higher drift rate for the response-compatible flanker trials as opposed to the response-incompatible trials. Yet again the analysis did not show any of the expected effects. However, we found that high-power appraisal improved task performance, indicated by fewer errors and faster responses. The DDM analysis suggested that this difference can be attributed to a higher drift rate, a higher non-decision time, and a lower decision boundary. As the flanker task is also a measure of executive control (Posner & Rothbart, 2007) and thus does not purely capture breadth of attention, we sought to replicate the findings with a different breadth of attention measure.

In **Experiment 2**, 215 participants completed the experiment, of whom 196 were included in the final sample after the pre-processing of the data. The experiment was mostly identical to Experiment 1, with the main difference being the new dependant variable measure. In Experiment 2, we used the undirected version of the Navon task (Gable & Harmon-Jones, 2008; Navon, 1977) which does not include an inherent response conflict like in the flanker task. In this task, participants have to respond to large letters (e.g., "H") made out of small letters (e.g., "L"), known as the global and local levels of the stimulus, respectively. In the undirected version of the task, only one of the target letters ("H" or "T" in our experiment) is used in the stimulus. The target letter can be either on the global level (e.g., an "H" made out of small "L-s") or on the local level (e.g., a "F" made out of small "T-s"). According to the paradigm, broad breadth of attention facilitates the processing of global-level target letters, whereas narrow breadth of attention facilitates the processing of local-level target letters.

Similar to the previous experiment, we expected that breadth of attention is narrower in goal incongruent and high-power trials resulting in a) faster reaction times, b) fewer errors, and c) higher drift rates for local Navon trials. And, accordingly, we expected that breadth of attention is broader in goal congruent and low-power trials resulting in a) faster reaction times, b) fewer errors, and 3) a higher drift rate for global Navon trials. As with Experiment 1, we did not observe any appraisal effects on breadth of attention, and, thus, we replicated the null findings from the previous experiment. In addition, we replicated the high-power effect on task performance. In high-power trials participants were faster and made fewer errors. The DDM analysis suggested that this effect can be attributed to a higher drift rate and a lower decision boundary, meaning that information was gathered more quickly and that less information was needed to make a decision, respectively.

The finding that high-power appraisal improved cognitive efficiency can be linked to accounts emphasizing motivational impacts on cognitive control (Botvinick & Braver, 2015; Pessoa & Engelmann, 2010). According to this perspective, more cognitive resources are allocated for a task when the anticipated rewards for investing cognitive resources outweigh the anticipated costs. High-power appraisal could have a similar effect on cognitive resource allocation, including attention allocation. In the experiment, having control over the outcome of the trial increased the chances for a more favourable outcome and thus could have overshadowed the costs of allocating cognitive resources for the task. Interestingly, the high-power effect in this study can be linked to the goal relevance effect on attention allocation in Study I where attention allocation was driven by goal relevance appraisal. It could be argued that high-power appraisal, by increasing the likelihood of the anticipated rewards, enhanced attention allocation for the task and thus improved task performance.

In conclusion, the results from both experiments did not support our hypothesis that appraisals influence breadth of attention. Instead, by using Bayesian analysis methods, we found substantial support for the null hypothesis that there are no appraisal effects on breadth of attention. In addition, by analysing the data based on the self-reported rating of stimulus valence ("This icon was positive for me.") and of motivational intensity ("This icon gave me motivation to act."), we showed that alternative explanations also did not explain our results. Thus, the null finding questions not just our initial hypothesis but also other, more prominent, alternative explanations.

It is important to consider whether the experiments failed in some crucial aspect, which could have influenced the detection of an effect. Based on the several design choices and manipulation checks listed below, we can argue that the results of the study are valid. Firstly, both experiments had large samples and used within-subjects designs, and thus they likely did not suffer from a lack of statistical power. Secondly, we used several steps to assure that our web-based data collection was reliable. To control for the size of the stimuli, we asked participants to calibrate their computer screen before the task. In addition, participants were asked to sit at a certain distance from the screen – in an additional analysis the reported distance from the screen did not show any effects on the overall results. Thirdly, the results from the post-experiment questionnaire revealed that the manipulation of appraisals was likely successful. In this questionnaire we asked participants to rate the different events in the study according to the appraisal dimensions. The patterns of the ratings matched the expected event (e.g., high-power trials were assessed more highly on the power scale).

5. FUTURE DIRECTIONS: INDIVIDUAL DIFFERENCES IN PERSONALITY

In this section, I will propose that future research could benefit from considering the role individual differences, especially the extraversion and neuroticism traits of personality. First, I will give a brief overview of these traits and their relationship with affective reactivity. Then, I will give an overview of our study, where we examined the relationship between self-report and implicit measures of these personality traits.

5.1. Extraversion and neuroticism linked to affective reactivity

The results from the previous study questioned our current proposal but also cast doubt on the dominant theories that describe affective effects on breadth of attention. That said, there are other studies which show no affective effects on breadth of attention (Bruyneel et al., 2013; van Steenbergen, 2015; Vanlessen et al., 2016). One possible explanation for the inconsistent findings may be the focus on average group-level performance as opposed to individual differences. There is reason to believe that individual differences can add significant variability to visual attention performance. Indeed, studies have shown that individual differences matter in low- and high-levels of visual processing, for instance in colour vision (Lafer-Sousa et al., 2015) and ensemble perception (Haberman et al., 2015; for a review see Tulver, 2019). Research also suggests that breadth of attention can vary as a function of individual characteristics, such as age (Lawrence et al., 2018), working memory capacity (Kreitz et al., 2015), and personality (Wilson et al., 2016).

When considering affective effects on visual attention, two core personality dimensions stand out as possible moderators of affective effects on attention: extraversion and neuroticism (Costa & McCrae, 1995; Eysenck, 1967). Extraversion is usually characterized by assertiveness, high activity levels, impulsivity, but also by optimism and positive emotions (Watson et al., 1994). neuroticism, on the other hand, is usually characterized by a disposition towards negative feelings like anxiety, self-consciousness, and emotional instability (Watson et al., 1994). In addition, both traits have been linked to affective reactivity including the frequency, intensity, and duration of positive and negative emotions, respectively (Verduyn & Brans, 2012) Furthermore, both traits are also linked to emotion regulation strategies. People high in extraversion use more effective methods, such as reappraisal, whereas people high in neuroticism tend to use less effective methods, such as suppression (Barańczuk, 2019).

Due to the link between these personality traits and emotional reactivity, it is quite reasonable to assume that these traits could moderate affective effects on attentional dynamics. For instance, as people high in extraversion are better at regulating negative emotions (Barańczuk, 2019), they could be less impacted by negative emotion manipulation compared to people with low extraversion. Studies have indeed demonstrated that both extraversion and neuroticism can moderate emotional effects on visual attention (Bendall et al., 2021; Bredemeier et al., 2011). For example, one study showed that after negative emotion manipulation, participants high in extraversion performed better than participants with low extraversion (Bendall et al., 2021).

It is not entirely clear under which circumstances these traits moderate affective effects on attention. Considering that there are quite a lot of inconsistencies in the literature dealing with affective effects on breadth of attention, future research in this field could benefit from examining whether extraversion and neuroticism explain some of the inconsistencies. In the current thesis, I raise this question as a potential avenue for future research, which I do not directly address with empirical research. However, I will present a study that makes a contribution to the assessment methods of personality that can be leveraged in a future effort to relate personality traits to the affective impacts on attention control.

STUDY III: Explicit and implicit extraversion and neuroticism measures

In assessing individual differences, personality psychology relies heavily on well-established self-report methods. It is well-known, however, that responses to self-report questions can be biased by different factors, such as a distorted self-concept and social desirability (Perugini & Banse, 2007; Perugini et al., in press). Some of these biases can be mitigated by peer-reports but these can be biased in their own ways (Konstabel et al., 2006; Vazire, 2010). Researchers have therefore hoped that some of the limitations of explicit measures can be addressed by indirect or implicit measures, where psychological attributes are inferred from specially designed reaction-time tasks. In the context of personality assessment, reaction times are thought to reflect psychological attributes with little or no bias resulting from conscious self-reflection (De Houwer & Moors, 2010). These kinds of methods could provide an interesting addition to classical self-report questionnaires, especially because implicit measures could tap into aspects of personality traits that are connected to more spontaneous behaviour (Steffens & Konig, 2006).

However, more research is needed to better understand how implicit reflections of personality relate to self-report reflections. Existing literature suggests that explicit and implicit personality measurements are correlated, but not perfectly and not always (Siers & Christiansen, 2013; M. Steffens & Konig, 2006). This pattern can be interpreted in at least one of two ways. One possibility is that explicit and implicit methods tap into the same construct with their non-shared variance simply reflecting methodological or confounding sources of variance. Another possibility is that explicit and implicit measures of personality traits reflect at least partially distinct constructs. The aim of Study III was to examine whether explicit and implicit measures of extraversion and neuroticism measure the same or different aspects of the respective personality dimensions.

Conceptually, there are reasons to think that personality self-reports and the Implicit Association Test (IAT) tap into the same constructs. Generalized personality judgments are, to a large extent, based on semantic memory (Klein, 2013) rather than specific episodic memories which become relevant only when people need to describe themselves in novel situations (Klein et al., 1997). Therefore, self-reports are not necessarily more reflective and less automatic than responses in the IAT. At the same time, there is also support for the idea that explicit and implicit self-concepts of personality capture related but distinct constructs (Nosek & Smyth, 2007; Schnabel et al., 2008; Siers & Christiansen, 2013). Studies have shown low to moderate correlations between explicit and implicit measures of the Big Five personality traits, indicating that the measures do not overlap entirely (De Cuyper et al., 2017). The interpretation of these findings, however, needs to take into account differences in the study designs.

To tease these possibilities apart, we conducted an extensive web-based data collection to increase statistical power compared to some previous studies which have shown inconsistent results (Schmukle & Egloff, 2005; Siers & Christiansen, 2013; Steffens & König, 2006). To assess the implicit construct of personality we used the IAT (Greenwald, McGhee, & Schwartz, 1998). The IAT has been used to asses different implicit constructs, such as self-esteem, stereotypes, and various attitudes (Lane et al., 2007). Recently it has also been adapted to measure the implicit self-concept of personality (De Cuyper et al., 2017; Dentale et al., 2014). In the IAT, participants are asked to categorize stimuli representing the concepts under study. For example, in an extraversion IAT, four different categories are used, where two of them represent opposite ends of the personality dimension (e.g., "extraversion" vs "introversion"), and the other two represent the self-concept ("me" vs "others"). The stimuli from each category (e.g., "talkative", "shy", "mine", "they") are presented one at a time on-screen. The participants are asked to categorize the stimuli according to the category labels on the left and right sides of the screen. Importantly, in different blocks, the different categories share a response option. For instance, in one block "extraversion" and "me" share the same response button (e.g., left keyboard button), whereas in another block "extraversion" and "other" share the same response button. It is assumed that a stronger relationship between categories is reflected in faster responses when the categories share the same physical response.

A total of 442 students participated in the study. Most participants completed two self-report measures, a personality questionnaire (Short 5; Konstabel et al., 2012) and a questionnaire composed of the adjectives in the IAT attribute categories. In addition, the participants were asked to complete two IATs which were designed to assess implicit extraversion and implicit neuroticism.

First, we expected to find low-to-moderate correlation between the explicit and implicit methods (De Cuyper et al., 2017; Schmukle & Egloff, 2005; Siers

& Christiansen, 2013). In accordance with this expectation, we found a moderate correlation between the extraversion self-report and extraversion IAT (r = .41), as well as a small correlation between the corresponding neuroticism measures (r = .25). Importantly, we observed stable correlations with extraversion and neuroticism measures by using a larger sample size than some previous studies, which have shown inconsistent results (Schmukle & Egloff, 2005; Siers & Christiansen, 2013; Steffens & König, 2006).

Second, the main aim of the study was to test the fit of two conceptual explanations for the observed correlations between explicit and implicit measures, into two mutually exclusive statistical models: 1) the same trait model proposing that explicit and implicit personality scores reflect the same construct, and 2) the different trait model proposing that explicit and implicit scores reflect different constructs. The same trait model assumes that explicit and implicit measures tap into the same personality trait. The different trait model proposes, instead, that explicit and implicit measures reflect related but distinct traits. We found that the different trait model provided a better fit for our data, indicating that explicit and implicit methods reflect related but distinct constructs. This finding is in line with previous research showing that implicit and explicit personality measures are related but tap into different aspects of personality (Schnabel et al., 2008; Siers & Christiansen, 2013). For example, Siers & Christiansen (2013) found similar results for three personality dimensions – extraversion, conscientiousness and emotional stability. Our results also mirror more distant findings: that implicit and explicit attitudes towards different objects reflect somewhat distinct constructs (Nosek & Smyth, 2007).

The results of the study support the view that explicit and implicit measures tap into different aspects of the same personality trait. Although the validity of personality IAT is somewhat questioned (Lazarević et al., 2021), there are reasons to believe that implicit measures provide some additional information over and above self-report methods. For instance, it is possible that the aspects of personality reflected in implicit measures are more directly connected to emotional reactivity than aspects reflected in explicit measures. There are two lines of research supporting this claim. First, some studies have demonstrated that personality IAT predicts spontaneous behaviour which can be related to automatic aspects of emotional reactivity (Asendorpf et al., 2002; Steffens & König, 2006). Second, implicit positive or negative self-attitudes have been linked to spontaneous everyday affective experiences (Conner & Barrett, 2005). The same could be true for implicit extraversion and neuroticism, as both traits have been linked to positive and negative self-concept, respectively. In summary, future research could make use of both explicit and implicit methods to map out whether personality dimensions moderate affective effects on attention. Implicit extraversion and neuroticism scores, by tapping into more spontaneous and automatic associations, could provide additional information about participants' emotional reactivity, in addition to their self-report counterparts.

6. SUMMARY AND CONCLUSIONS

This dissertation took a closer look at the relationship between affect and visual attention. More specifically, it was proposed that two aspects of attention control, allocation of attention and breadth of attention, are directly influenced by one specific component of affect – the appraisal component.

Affective effects on attention control have been attributed to different aspects of affect, such as arousal (Mather & Sutherland, 2011), valence (Fredrickson, 2004), and motivational intensity (Gable & Harmon-Jones, 2010b). However, it seems that none of these approaches is able to explain all the available findings. To approach this problem, it is best to view affect as a multicomponent system, where the appraisal-driven synchronized activity of different components, such as the motivational and motor-expression components, generates the overall affective experience (Moors, 2010). According to this view of affect, it can be argued that some of the previous explanations attribute the affective effects on attention control to the activity of the whole affect system, whereas other explanations attribute the effects to specific components, such as the motivational component. Considering that the appraisal process is thought to trigger affective reactions by orchestrating changes in other affect components (Scherer, 2009b), it is worth more systematically exploring the possibility that attention control is influenced directly by the appraisal process. To this end, two focal studies in this dissertation have experimentally investigated appraisal effects on different aspects of attention control. First, in a methodologically-oriented study, we aimed to clarify the relationship between pupil size and different aspects of attention control. Next, we investigated the effects of two appraisals, goal relevance and goal congruence appraisal, on attention allocation. After that, we examined the effects of two appraisals, goal congruence and power appraisal, on breadth of attention. Finally, the dissertation proposed an avenue for future research into individual differences.

It is well-documented that pupil size reflects attention allocation to a specific stimulus; however, it is less-well documented as to whether pupil size also reflects changes in breadth of attention. In **Study IV**, we showed that the broadening of breadth of attention was associated with larger pupil size. One possible reason for this could be that the attentional system uses pupil size as one of the mechanisms through which it achieves the broadening of attention. However, contrary to this view, we did not find that behavioural effects of breadth of attention were mediated by pupil size. This suggests that the relationship between breadth of attention and pupil size could be purely correlational. For instance, it is possible that the mechanisms that regulate breadth of attention may separately influence the neural pathways controlling pupil dilation and constriction, the parasympathetic and sympathetic pathways of the autonomic nervous system, respectively. Further research is necessary to clarify whether dilating the pupil helps to tune visual attention (Mathôt, 2020) or whether the relationship is indeed correlational.

In the first focal study of the dissertation, **Study I**, we found support for the idea that goal relevance appraisal is one of the main drivers of attention allocation. In addition, by investigating the independent effects of goal relevance and goal congruence appraisals, we showed that goal congruence does not influence attention allocation over and above goal relevance. As goal congruence appraisal contributes to the valence of the subjective experience (Frijda et al., 1989), this finding has interesting implications for negativity and positivity bias accounts (Rozin & Royzman, 2001; Yiend, 2010). The former account suggests that negative events and stimuli are prioritized because of their negative valence, with the latter account suggesting that the same is true for positive events and stimuli. The current findings, however, support the view that the positivity- and negativity-bias effects could be attributed to different levels of goal relevance. For example, negative stimulus, such as an angry face in a crowd, could be prioritized in attention because it is appraised automatically as more dangerous and thus more relevant. On a broader level, the current findings are in line with different research that also emphasizes the role of relevance in attention allocation (Maratos & Pessoa, 2019; Scherer, 2009b). This broad support shows that it is a very successful and productive way to describe affective effects on attention allocation. Firstly, as shown with negativity- and positivity-bias, this approach can be used to describe prior findings from a new angle. Secondly, considering that the appraisal process can be automatic (Moors, 2010), this explanation is also in line with the idea that affective stimuli can capture attention in an automatic manner (Yiend, 2010).

In **Study II,** we did not find support for the dissertation's second main hypothesis that appraisals influence breadth of attention. In addition, alternative explanations, focusing on the valence and motivational value of the stimuli (Fredrickson, 2004; Gable & Harmon-Jones, 2010b), did also not show affective influences on breadth of attention. Overall, the null findings suggest that a thorough reassessment of the affective effects on breadth of attention is needed. For instance, future research should consider systematically examining the needed duration and intensity of affect manipulation for it to have an impact on attentional breadth. On the other side, it should also be considered that the current finding, alone, does not definitively disregard appraisal effects. For instance, it is possible that in our study the appraisal manipulation was too weak to trigger the appraisal process. To be more certain about the results, future studies should measure the effectiveness of their appraisal manipulation with an objective method, such as electroencephalography (e.g., van Peer et al., 2014), instead of an indirect manipulation check method, like the post-experiment questionnaire in our study. Similarly, it should be considered that the findings cannot be generalized to the entire breadth of attention construct. This position is supported by research showing that it is not a unitary construct because different paradigms seem to tap into different aspects of breadth of attention (Dale & Arnell, 2013). Thus, it is also advisable to replicate the findings with different dependent variable measures, such as a functional field of view task (Kreitz et al., 2015).

Finally, I proposed that taking into account individual differences could potentially be a fruitful avenue for future research, as they could moderate the effects of affect on attention control. In particular, future research should consider the effects of the extraversion and neuroticism personality traits, as both are linked to affective reactivity (Verduyn & Brans, 2012). I introduced the idea of using both classical self-report measures as well as implicit measures because there is reason to believe that the latter reflects the affective reactivity associated with the respective personality dimension. However, it is not entirely clear whether the two methods reflect the same or different aspects of the personality dimension. In **Study III**, we demonstrated that the two methods indeed measure distinct aspects of the respective personality dimensions. Future studies should clarify whether, and to what extent, the implicit measures reflect affective reactivity associated with extraversion and neuroticism.

In conclusion, the current thesis used the appraisal framework of emotion to explain the relationship between affect and attention control. Not all main hypotheses about the appraisal effects on attention control were supported by the presented research. One the one hand, the dissertation illustrated that appraisal framework is very useful for explaining affective effects on attention allocation. One the other hand, in the case of breadth of attention, it seems that more research is needed to understand when affect impacts breadth of attention. Besides investigating affective effects on breadth of attention, we exemplified the value of pupillometry for research into attention control.

ACKNOWLEDGEMENTS

I am deeply grateful to my supervisors, Andero Uusberg and Jüri Allik, for their guidance and support. It was a privilege to learn the different aspects of research in a group that values scientific curiosity. I am especially thankful to Andero for inspiring and advising me throughout my studies, from my humble bachelor's thesis to the current doctoral dissertation.

I am also very thankful to Kenn Konstabel and Sander Nieuwenhuis for their collaboration, which has given me unique insight into different areas of research. In addition, the six-month period visiting Sander's lab in Leiden provided an excellent opportunity to expand my scientific horizon. Also, I would like to thank other co-authors for their contribution and for broadening my understanding of different scientific questions.

Throughout my PhD studies I had the opportunity to be a part of the wonderful collective of the Institute of Psychology. I thank all my colleagues for creating a friendly and helpful work environment. I am very grateful to my fellow PhD students for sharing the ups and downs of PhD studies and academic life in general. Thank you Annegrete Palu, Hedvig Sultson, Kristiina Averin, Liina Juuse, Liis Kask, and many others! Special thanks to Kadi Tulver and Richard Naar for their support and encouragement, and for countless thought-provoking discussions about scientific research.

Finally, and most importantly, I would like to thank my friends and family for their support and patience, as at times social life has had to make way for research. Special thanks to Paul Gardner for his thoughtful comments and for proofreading the dissertation. Lastly, I am especially grateful to my mother for encouraging me to pursue a career in science.

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SUMMARY IN ESTONIAN

Afektiivsete tõlgenduste mõju tähelepanu kontrollile

Doktoritöö keskendus afekti ja visuaalse tähelepanu seoste uurimisele. Peamiselt pakuti välja, et tähelepanu kontrolli aspektidest on tähelepanu jaotus ja tähelepanu haardeulatus mõlemad otseselt mõjutatud ühe konkreetse afekti komponendi poolt – afektiivsete tõlgenduste poolt.

Eelnevalt on afekti mõju tähelepanu kontrollile kirjeldatud läbi erinevate afekti omaduste nagu valents, intensiivsus ja motivatsiooniline tugevus. Ometi ükski nendest seletustest ei suuda kirjeldada kõiki olemasolevaid tulemusi. Sellele probleemile lähenemiseks on kasulik esmalt mõtestada lahti afekti olemus. Afekti saab vaadata kui mitmest erinevast komponendist koosnevat süsteemi, mille puhul tekib afektiivne kogemus nende erinevate komponentide (nt. motivatsiooniline ja tõlgenduste komponent) aktiivsuse alusel. Seejuures peetakse afektiivseid tõlgendusi seda süsteemi juhtivaks komponendiks. Afektiivsed tõlgendused annavad hinnangu olukorra motivatsioonilisele väärtusele, millest lähtudes kujuneb teiste komponentide aktiivsus. Näiteks tõlgendus, et sündmus on hetke eesmärkidega selgelt ebakõlaline, võib tekitada tungi eemalduda ja kutsuda esile negatiivse tunde. Kui võtta aluseks selline afekti käsitlus, siis saame jaotada eelnevad seletused afekti ja tähelepanu seostele kaheks. Esiteks, osad seletused rõhutavad afektiivse süsteemi üldise aktiivsuse rolli tähelepanu kontrollis. Teiseks, osad seletused keskenduvad aga selgemalt afektiivse süsteemi üksikutele komponentidele ja nende rollile tähelepanu kontrolli mõjutamisel, näiteks nagu motivatsioonilise intensiivsuse rollile. Käesolevas doktoritöös pakuti välja alternatiivne seletus, mis on kooskõlas teise lähenemisega. Täpsemalt pakuti välja, et afekti mõju tähelepanu kontrollile saab seletada afektiivsete tõlgenduste tasandil. Kuna tõlgendused omavad afektiivse protsessi käivitamisel ja teiste afekti komponentide aktiivsuse kooskõlastamisel olulist rolli, siis võiks arvata, et neil on mõju ka tähelepanu kontrollile. Selle küsimuse uurimiseks vaadati antud doktoritöö kahes peamises katses, kas teatud tüüpi tõlgendused ehk tõlgendusdimensioonid omavad mõju erinevatele tähelepanu kontrolli aspektidele – tähelepanu jaotusele ja tähelepanu haardeulatusele. Esmalt keskendus doktoritöö aga ühele metodoloogilisemale aspektile. Nimelt vaadati lähemalt pupilli reaktiivsuse ja tähelepanu kontrolli erinevaid omavahelisi seoseid. Järgmiseks uuriti kahe tõlgendusdimensiooni mõju tähelepanu jaotusele ning seejärel uuriti kahe tõlgendusdimensiooni mõju tähelepanu haardeulatusele. Lõpuks kaasati afekti ja tähelepanu kontrolli seoste uurimisse individuaalsete erinevuste dimensioon.

Varasemalt on näidatud, et pupilli reaktiivsus peegeldab muuhulgas tähelepanu jaotust kindlale stiimulile, aga vähem on teada, kas pupill on seotud ka muutustega tähelepanu ulatuses. **Uuringus IV** näitasime, et laiem tähelepanu ulatus oli seotud suurema pupilliga. Seose põhjuseks võib olla see, et visuaalse tähelepanu süsteem kasutab pupilli suuruse reguleerimist, et saavutada kitsam või laiem tähelepanu haardeulatus. Meie katse aga seda seletust ei toetanud, kuna tähelepanu haardeulatuse käitumuslikud efektid ei olnud vahendatud pupilli suuruse poolt. Vahendusefekti puudumine viitab pigem sellele, et seos on lihtsalt korrelatiivne. Näiteks on võimalik, et tähelepanu ulatust mõjutavad süsteemid omavad eraldiseisvalt mõju ka närvisüsteemidele, mis kontrollivad pupilli kitsenemist ja laienemist (parasümpaatilisele ja sümpaatilisele närvisüsteemile). Tulevased uuringud peaksid täpsemalt selgitama välja, kas pupilli suuruse reguleerimine aitab kaasa tähelepanu haardeulatuse efektide saavutamisele või on see seos siiski pigem korrelatiivne.

Doktoritöö järgmises uuringus, **Uuringus I**, leidsime kinnitust lähenemisele, et relevantsuse tõlgendusdimensioon (ehk olukorra tajutud olulisus) juhib tähelepanu jaotust. Lisaks sellele kõrvutasime relevantsuse ja kongruentsuse (olukorra tajutud kasulikkuse) tõlgendusdimensioonide mõju tähelepanu jaotusele ja leidsime, et viimane ei omanud eraldiseisvat efekti tähelepanule. Varasemas kirjanduses on kongruentsuse tõlgendusdimensiooni seostatud nii positiivse kui negatiivse afekti seisundi kujunemisega. Antud tulemustel on seega olulised implikatsioonid nendele uuringutele, kus on viidatud, et eelisjärjekorras töödeldakse negatiivseid või positiivseid stiimuleid (negatiivsuse ja positiivsuse kalle). Antud katse tulemused toetavad ideed, et negatiivsuse või positiivsuse kalde asemel juhindub tähelepanu stiimuli tajutud olulisusest. Näiteks võib negatiivne stiimul tõmmata tähelepanu, kuna seda hinnatakse automaatselt ohtlikumaks ja seega ka olulisemaks. Laiemalt vaadates toetab antud uuring mitmeid eelnevaid uuringuid ja teooriaid, mis samuti rõhutavad vähemal või suuremal määral seda, et tähelepanu juhib stiimuli tajutud olulisus. Selline laialdane kinnitus näitab, et tegemist on väga tõhusa viisiga, kuidas seletada afektiivset tähelepanu. Esiteks võimaldab see lähenemine seletada varasemaid uuringuid uue nurga alt, nagu negatiivse ja positiivse kalde puhul. Teiseks, arvestades, et tõlgenduste protsess võib toimuda automaatselt, on see lähenemine kooskõlas ka asjaoluga, et tähelepanu jaotamine ise võib toimuda väga kiirelt ja automaatselt.

Uuringus II me ei leidnud kinnitust doktoritöö teisele peamisele hüpoteesile, et tõlgendusdimensioonidel on mõju tähelepanu haardeulatusele. Lisaks näitasime, et afekti mõju tähelepanu haardeulatusele ei ilmnenud ka siis, kui tulemusi analüüsiti teistest teooriatest lähtuvalt (valentsi ja motivatsioonilise intensiivsuse teooriatest). Üleüldiselt rõhutavad need nulltulemused, et järgnevad uuringud peaksid tõsisemalt kontrollima selle efekti paikapidavust. Näiteks võiks süstemaatilisemalt uurida, missuguse pikkuse ja tugevusega afekti manipulatsiooni läheb vaja, et see avaldaks mõju tähelepanu haardeulatusele. Teisalt tuleks arvestada ka asjaoluga, et antud uuring üksi ei ole veel lõplik kinnitus tõlgendusdimensioonide efekti puudumisele. Näiteks ei pruukinud meie katses tõlgenduste manipulatsioon olla piisavalt tugev, et käivitada tõlgenduste protsessi. Tulevased katsed võiksid kaudse manipulatsiooni efektiivsuse kontrolli asemel (meie katses oli selleks katsejärgne küsimustik) kasutada meetodit, mis võimaldab objektiivsemalt hinnata tõlgendusdimensioonide manipulatsiooni efektiivsust, näiteks on selleks eesmärgiks kasutatud elektroentsefalograafiat. Sarnaselt tuleks kaaluda, et antud tulemus ei pruugi olla üldistatav tervele tähelepanu ulatuse nähtusele. On uuringuid, mis näitavad, et erinevad tähelepanu haardeulatuse mõõdikud mõõdavad selle nähtuse erinevaid aspekte. Seega on soovituslik korrata antud tulemusi uute mõõdikutega, nagu näiteks funktsionaalse nägemisala katse.

Lõpuks pakuti doktoritöös välja, et tulevased uuringud võiksid arvestada individuaalsete erinevustega, sest need võivad modereerida afekti mõju tähelepanu kontrollile. Eriti tuleks kaaluda ekstravertsuse ja neurootilisuse isiksuseomaduste mõõtmist, sest mõlemaid seostatakse afektiivse reaktiivsusega. Töös rõhutati, et lisaks tavalistele enesekohastele küsimustikele võiks kasutada implitsiitseid isiksuseomaduste teste, mis eeldatavasti tabavad isiksuseomaduse afektiivse reaktiivsusega seotud aspekte. Ometi ei ole veel täiesti selge, kas need mõõdikud on pigem kattuvad või annavad siiski erinevat informatsiooni uuritava omaduse kohta. **Uuringus III** näitasime, et enesekohased ja implitsiitsed mõõdikud tõepoolest annavad pigem erinevat infromatsiooni mõõdetava isiksuseomaduse kohta. Tulevased uuringud võiksid täpsemalt vaadata, kas ja mil määral implitsiitsed isiksuseomaduse mõõdikud peegeldavad ekstravertsusega ja neurootilisusega seostatud afektiivset reaktiivsust.

Kokkuvõttes, käesolev doktoritöö kasutas afekti tõlgendusteooria raamistikku, et seletada afekti ja tähelepanu kontrolli seoseid. Esitatud uuringud ei kinnitanud aga kõiki püsitatuid hüpoteese. Ühest küljest illustreeris töö, et tõlgendusteooria raamistik on väga väärtuslik ja tõhus tööriist tähelepanu jaotuse efektide seletamiseks. Teisest küljest tõid töös esitatud uuringud välja, et afekti mõju tähelepanu haardeulatusele vajab veel tõsisemat uurimist, et selgitada välja, millal täpselt afekti mõju avaldub. Lisaks demonstreeris antud töö pupilli reaktiivsuse väärtust tähelepanu kontrolli protsesside uurimisel.

PUBLICATIONS

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