INTUITION:
A UNIFIED PHENOMENON?

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PREFACE

Chapter 2 is based on the following manuscript:

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I developed the idea and wrote the manuscript. I thank Sascha Topolinski for his valuable input on some passages.

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We developed the idea for the project together. I programmed the experiments and collected the data. We analyzed the data together and co-wrote the manuscript.

Chapter 4 is based on the following manuscript:

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Sascha Topolinski and I developed the experiment together. I programmed the experiment, collected the data, and conducted the data analyses with valuable supervision from Andreas Glöckner. I wrote the manuscript, which benefited from the insightful contributions of Sascha Topolinski.

ABSTRACT

In the existing literature, perspectives on intuition have been remarkably diverse. Some authors have described intuition as a sophisticated unconscious mechanism, while others have argued that it is based on simple automatic principles. Considering this conceptual ambiguity, the current dissertation presents a meta-perspective on intuitive-automatic phenomena by exploring the field's conceptual boundaries. Chapter 1 provides an overview of the core features of intuition as identified in the literature. Chapter 2 traces the development of different theoretical perspectives on intuition, outlining the major theories and key ideas that have influenced them. Chapter 3 then presents a modern adaptation of a classic measurement approach that has been used in the study of intuition and insight problem-solving. In Chapter 4, the relationships between this instrument and other prominent measures are explored, as well as their associations with personality traits and cognitive abilities. The findings suggest that intuition is a diversely operationalized construct, with existing measures capturing a variety of cognitive phenomena that are, for the most part, unrelated. Accordingly, Chapter 5 concludes by discussing the central challenges in conceptualizing intuition as a research construct.

DEUTSCHE ZUSAMMENFASSUNG

In der bestehenden Literatur sind die Perspektiven auf Intuition bemerkenswert vielfältig. Einige Autoren haben Intuition als einen hochentwickelten unbewussten Mechanismus beschrieben, während andere argumentieren, dass sie auf einfachen automatischen Prinzipien beruht. Angesichts dieser konzeptionellen Mehrdeutigkeit bietet die vorliegende Dissertation eine Metaperspektive auf intuitiv-automatische Phänomene, indem sie die konzeptionellen Grenzen des Forschungsfelds untersucht. Kapitel 1 gibt einen Überblick über die Kernmerkmale der Intuition, wie sie in der Literatur beschrieben wurden. Kapitel 2 zeichnet die Entwicklung verschiedener theoretischer Perspektiven auf Intuition nach und skizziert die wichtigsten Theorien und Schlüsselideen, die sie geprägt haben. Anschließend stellt Kapitel 3 eine moderne Adaption eines klassischen Messansatzes vor, der in der Erforschung von Intuition und Einsicht verwendet wurde. In Kapitel 4 werden die Beziehungen zwischen diesem Instrument und anderen etablierten Messverfahren sowie deren Zusammenhänge mit Persönlichkeitsmerkmalen und kognitiven Fähigkeiten untersucht. Die Ergebnisse legen nahe, dass Intuition ein vielfältig operationalisiertes Konstrukt ist, wobei die bestehenden Messansätze eine Vielzahl kognitiver Phänomene erfassen, die größtenteils nicht miteinander in Zusammenhang stehen. Dementsprechend schließt Kapitel 5 mit einer Diskussion der zentralen Herausforderungen bei der Konzeptualisierung von Intuition als Forschungskonstrukt.

CHAPTER 1: INTRODUCTION

Most human thinking and reasoning is a mixture of conscious and unconscious components (Baars & Gage, 2010). Most of the time, we have a good understanding of the cognitive processes that we consciously engage in, for example, when we solve a math problem or plan our grocery shopping list. However, we tend to underestimate the impact and scope of mental processes that take place without our conscious awareness (e.g., Baars & Gage, 2010; Dijksterhuis, 2004; Klein, 1993; Morewedge & Kahneman, 2010).

Nevertheless, unconscious processes are evident in many everyday situations. For instance, we often form rapid judgments about a person's personality just by looking at their facial features and nonverbal behavior (e.g., Ambady & Rosenthal, 1992, 1993; Todorov, 2017; Willis & Todorov, 2006). Similarly, we are able to acquire the underlying rules of foreign languages without studying them explicitly (e.g., Reber, 1993; Williams, 2009). Or, to give a less abstract example, when we go to a supermarket, we probably have an intuitive expectation of how much we will pay at the checkout (Hogarth, 2010).

Thus, although we may not be aware of them, unconscious mental processes pervasively influence our judgments, decisions, and behaviors (Baars & Gage, 2010; Bargh & Morsella, 2008). However, given that these processes occur unconsciously, it is not the processes themselves that we get aware of, but only their experiential outcomes. Put differently, while we may not be directly aware of our unconscious processes at work, we can perceive the feelings, signals, or interpretations that arise from them (cf. Glöckner & Witteman, 2010; see also Betsch, 2008; Hogarth, 2001; Topolinski & Strack, 2009b).

Perhaps the most fascinating manifestation of this is the phenomenon of *intuition*—a *feeling of knowing* (Metcalfe & Wiebe, 1987), a *hunch* (e.g., Bowers et al., 1990; Epstein et al., 1996), or a *gut feeling* (e.g., Deutsch & Strack, 2008; Gigerenzer, 2007) that arises spontaneously and without conscious deliberation (e.g., Haidt, 2001; Kahneman & Klein, 2009; Plessner et al., 2008; Topolinski, 2017; Vaughan, 1979). In this sense, intuition is a fundamentally subjective experience that generally lacks objective justification or evidence. Nevertheless, we probably have all experienced moments when we “just knew” something without being able to explain why—only to find out we were right.

Given that intuition can enable us to make surprisingly quick and often effective judgments, while apparently bypassing traditional logic and deliberate reasoning, the phenomenon is fascinating not only to laypersons but also to psychological researchers. However, while the term “intuition” may evoke mystical connotations, most researchers approach intuition as a cognitive phenomenon that is based on unconscious processes (cf. Betsch, 2008). From a psychological perspective, intuition therefore often refers to the process or outcome of unconscious mechanisms that retrieve and process information that cannot be made explicit (Hogarth, 2010).

However, while the accuracy of intuitive judgments may indeed be remarkable in certain domains (e.g., Ambady & Rosenthal, 1992; Baumann & Kuhl, 2002; Betsch & Glöckner, 2010; Reber, 1967), numerous studies have also highlighted that intuitive cognition has potential pitfalls. In particular, it has been argued that intuitive cognition tends to overlook critical information, resulting in judgments that are based on incomplete or misleading data (e.g., Gilovich & Griffin, 2002; Kahneman & Frederick, 2002; Tversky & Kahneman, 1974). More generally, various investigations have demonstrated that the accuracy of intuitive judgements can vary widely depending on contextual factors, individual expertise, and the nature of the task (e.g., Hogarth, 2001; Kahneman & Klein, 2009; Morewedge & Kahneman, 2010; Topolinski & Strack, 2009b). Thus, while our gut feelings may sometimes lead us to the right conclusions, they are not infallible and may even be biased in systematic ways (cf. Tversky & Kahneman, 1974).

Considering that intuition can at times be remarkably accurate, yet at other times flawed, the phenomenon still raises many questions: How can we best understand the working mechanisms behind intuitive processes? What implications does intuition have for our broader understanding of implicit cognition and cognitive abilities in general? And under what circumstances should individuals place trust in their intuitive hunches (cf. Hogarth, 2010)?

Although the answer to these questions may seem relatively straightforward when considering a particular theory, it is, in fact, far from clear or definitive when trying to integrate findings across the field. One of the reasons for this is that scholars have approached intuition from different theoretical frameworks and have used a wide range of methods to study it. In this respect, across the existing literature, perspectives on intuition have been remarkably diverse.

Some scholars have described intuition as a sophisticated unconscious mechanism that integrates vast amounts of information with minimal cognitive effort (e.g., Betsch & Glöckner, 2010; Dijksterhuis & Nordgren, 2006; Klein, 1993). Others have argued that intuition relies on cognitive shortcuts that lead to satisfactory, rather than optimal decisions (e.g., Gigerenzer & Brighton, 2009; Gigerenzer & Todd, 1999; Morewedge & Kahneman, 2010; Simon, 1955; Tversky and Kahneman, 1974). Further authors argue that intuition is the result of implicit learning (e.g., Hogarth, 2001; Reber, 1989), complex pattern recognition (e.g., Klein, 1993; Simon & Chase, 1973), or coherence perception (e.g., Bowers et al., 1990; Sobkow et al., 2018). Contrasting views suggest that intuitive judgments may result from simpler (e.g., Gigerenzer & Gaissmaier, 2011; Gigerenzer & Todd, 1999), or potentially even biased information selection mechanisms (e.g., Gilovich & Griffin, 2002; Tversky & Kahneman, 1974).

1.1 The Current Work

Considering the broad spectrum of implicit processes that have been labeled as "intuitive", an important question is: Can intuition be understood as a singular phenomenon, or does it merely reflect a loose collection of unconscious mechanisms that share superficial similarities?

Acknowledging the diverse and sometimes conflicting assumptions underlying intuition research, this dissertation project aims to provide a meta-perspective and explore the field's conceptual boundaries. Thus, rather than attempting to unify or reconcile different perspectives on intuition, the present work aims to examine the fundamental ideas, theories, and methodologies that have shaped our understanding of the phenomenon. In this respect, the focus of this thesis will be twofold:

First, I will explore how different schools of thought on intuition have evolved and on what premises they are based. Chapter 2 (unpublished manuscript) probes these questions by establishing a chronological framework, outlining the historical evolution of different perspectives and the major theories and key ideas that have influenced them.

Second, I will examine prominent psychometric methods originating from different perspectives on intuition, discuss their theoretical foundations, and explore whether there is common variance among these instruments. Accordingly, in Chapter 3 (published manuscript), I demonstrate a classic measurement approach by presenting a modern adaptation of an instrument that has been used in the study of intuition and insight problem-solving (see Chapter 1.3 on insight problem-solving). Building on this, in Chapter 4 (unpublished manuscript), I will evaluate the convergent validity of this very instrument alongside other tools in the field, while additionally examining their relationships with personality traits and cognitive abilities. Since Chapters 2, 3, and 4 are structured as independent manuscripts, each addresses its own thematic focus and includes a separate introduction and discussion. In Chapter 5, I will conclude by discussing the central problems with intuition as a research construct. In the remainder of Chapter 1, I will establish a conceptual foundation for the chapters to follow. I will begin by discussing the core features and defining aspects of intuition as identified in the literature.

1.2 What is Intuition?

From a phenomenological standpoint, intuition is often understood as *felt knowledge* that arises without conscious deliberation (Gigerenzer, 2007; Hogarth, 2001). In line with this view, intuition is commonly described as a sense of knowing, a hunch, or a gut feeling that arises automatically without a deliberate thought process guiding it (e.g., Bowers et al., 1990; Deutsch & Strack, 2008; Epstein et al., 1996; Gigerenzer, 2007; Haidt, 2001; Kahneman & Klein, 2009; Metcalfe & Wiebe, 1987; Plessner et al., 2008; Topolinski, 2017; Vaughan, 1979).

While the subjective experience of intuition is described relatively consistently in different theoretical accounts, intuition has otherwise been conceptualized in diverse and even contradictory ways (Dane & Pratt, 2009; Glöckner & Witteman, 2010; Hogarth, 2010; Topolinski, 2017). For instance, Lieberman (2000) has described intuition as “the subjective experience of a mostly nonconscious process that is fast, a-logical, and inaccessible to consciousness” (p. 111). Dane and Pratt (2007) have defined intuition as “affectively charged judgments that arise through rapid, nonconscious, and holistic associations” (p. 40). In contrast, Simon (1987) has emphasized the role of expertise, defining intuition as “analyses frozen into habit and the capacity for rapid response through recognition” (p. 63). And Kahneman (2002) has described intuition as “thoughts and preferences that come to mind quickly and without much reflection” (p. 449).

Given these varying perspectives, “there are as many meanings for the term *intuition* as there are people using it.” (Betsch, 2008, p. 3). Nevertheless, despite the lack of unified theory, there are some general features of intuitive processes on which most researchers agree (for a more detailed discussion of relevant characteristics, see e.g., Dane & Pratt, 2009; Glöckner & Witteman, 2010; Hogarth, 2001; Topolinski, 2017).

1.2.1 Intuitive Processes are Unconscious

First, as already discussed in the previous sections, nearly all conceptualizations of intuition suggest that intuitive processes are unconscious. That is, they are independent of intention and occur with little or no conscious awareness of the process itself (e.g., Betsch & Glöckner, 2010; Deutsch & Strack, 2008; Gigerenzer, 2007; Hammond, 1996; Hogarth, 2001; Kahneman & Klein, 2009; Lieberman, 2000).

Thus, unlike deliberate thought processes (for a discussion of features distinguishing deliberate and intuitive processes, see Betsch, 2008), intuitive processes are assumed to be relatively non-transparent to the individual. As Kahneman and Klein (2009) note, intuitive judgments "come to mind on their own, without explicit awareness of the evoking cues" (p. 519) or awareness of the cognitive processes that extract meaning from these cues.

This implies that individuals are typically unable to reflect on or articulate the reasoning behind their intuitive judgments and decisions. In other words, the intuitive thought processes per se cannot be cognitively penetrated, making it difficult for individuals to explain their gut feelings (e.g., Glöckner & Witteman, 2010; Hammond, 1996; Hogarth, 2001; Kahneman & Klein, 2009; Pretz & Totz, 2007; Topolinski & Strack, 2009b).

1.2.2 Intuitive Processes are Fast and Effortless

Another characteristic on which most theoretical accounts on intuition agree is that intuitive processes are fast and effortless. In this regard, various accounts emphasize that intuitive processes, compared to more analytical forms of thinking, occur rapidly and require little to no conscious effort (e.g., Ambady & Rosenthal, 1992; Epstein, 1990; Gigerenzer & Todd, 1999; Hammond, 1996; Hogarth, 2010; Kahneman & Frederick, 2002; Pretz & Totz, 2007; Stanovich & West, 2000; Topolinski, 2017; Topolinski & Strack, 2009b).

In fact, some definitions even place this characteristic at the core. For instance, Haidt (2001, p. 1029) states that "The most important distinctions (..) [between intuitive and deliberate processes] are that intuition occurs quickly, effortlessly, and automatically“. Similarly, Hogarth (2001, p. 14) notes that “the essence of intuition or intuitive responses is that they are reached with little apparent effort”. Thus, while speed may not characterize every type of intuitive process (see Dijksterhuis & Nordgren, 2006; Koriat & Levy-Sadot, 2001, for contrasting perspectives), the quick and effortless nature of intuitive processes is central to many definitions of intuition.

1.2.3 Intuitive Processes Evoke Feelings and Interpretations

Another widely recognized characteristic of intuitive processes is their capacity to evoke immediate feelings and interpretations (e.g., Betsch, 2008; Bless & Forgas, 2000; Gigerenzer, 2007; Glöckner & Witteman, 2010; Hogarth, 2010; Topolinski & Strack, 2009b). Different authors have referred to this experiential aspect of intuition in various terms. Some have labeled it as “a feeling of knowing“ (Metcalfe & Wiebe, 1987), “a hunch“ (e.g., Bowers et al., 1990; Epstein et al., 1996), or “a gut feeling“ (e.g., Deutsch & Strack, 2008; Gigerenzer, 2007). Others have referred to it as “a sense of confidence“ (Hogarth, 2010), “a message from within“ (Bless & Forgas, 2000), or “an understanding by feeling“ (Bastick, 1982).

Regardless of the employed terminology, it is this experiential output that appears to serve as the subjective basis for intuitive judgments, providing individuals with a sense of certainty while the underlying processes remain opaque (Betsch, 2008). Thus, while intuitive processes per se are assumed to operate unconsciously, there is widespread consensus that their output becomes consciously available as feelings or interpretations (cf. Glöckner & Witteman, 2010; see also Betsch, 2008; Hogarth, 2001; Topolinski & Strack, 2009b).

1.2.4 Intuitive Processes are Based on Learning

Further, although different authors diverge about the process through which intuitive hunches are generated, most agree that they do not simply appear out of nowhere but are grounded in prior learning experiences (e.g., Betsch, 2008; Glöckner & Witteman, 2010;

Hogarth, 2001; Kahneman & Klein, 2009; Lieberman, 2007; Reber, 1967; Simon & Chase, 1973). As Klein (2003) has put it: "Intuition is the way we translate our experiences into judgments and decisions." (p. 13). Building on this idea, many authors emphasize the role of prior experience in shaping intuitive judgments. For instance, Reber (1989) simply defines intuition as the outcome of an implicit learning experience. In line with this view, further authors suggest that intuition involves the recognition of patterns, prototypes, or action scripts stored in memory (e.g., Bowers et al., 1990; Dane & Pratt, 2009; Glöckner & Witteman, 2010; Kahneman & Klein, 2009; Klein, 1993; Simon & Chase, 1973).

Nevertheless, more recent work has emphasized that the effectiveness of learning depends on repeated exposure to relevant and valid environments (for an in-depth discussion, see Hogarth, 2001; Kahneman & Klein, 2009). This highlights the limitations of intuition in domains that are unfamiliar to the individual or when past learning experiences do not align with current demands.

1.3 What Differentiates Intuition from Other Unconscious Phenomena?

Furthermore, although intuition has been defined in broad terms, it is important to note that not all unconscious processes that function autonomously can be classified as intuitive. In this respect, several other implicit phenomena are typically distinguished from it. These include all kinds of innate mechanisms, such as reflexes and instinctual behavior patterns, which operate without conscious awareness yet are mostly innate and not informed by prior learning experiences (Betsch, 2008; Hogarth, 2010). Thus, while reflexes and instincts refer to innate, biological drives that are probably hardwired, intuition is understood as a rapid, unconscious form of knowing based on experience (e.g., Hogarth, 2001; Klein, 2003; Reber, 1967; Simon & Chase, 1973).

In addition to distinguishing intuition from innate processes, it is also important to contrast it with related phenomena, such as insight. Whereas intuitive processes involve a sense of knowing, without being able to explain how (see e.g., Bolte & Goschke, 2005; Koriat & Levy-Sadot, 2000; Shirley & Langan-Fox, 1996; Vaughan, 1979), *insight* refers to a moment of sudden understanding that often occurs after a period of unconscious incubation (e.g., Bowden et al., 2005; Topolinski & Reber, 2010; Zander et al., 2016). While both involve unconscious mechanisms, insight involves recognizing the logical connection between a problem and its solution, while intuition does not involve such explicit understanding (Dane & Pratt, 2009). Nevertheless, as noted by Hogarth (2010), although insight into a problem can arise through conscious cognitive processes, it can also be achieved intuitively. Correspondingly, other authors have emphasized that intuitive processes can be the precursor of certain types of insight (see e.g., Bowers et al., 1995; Öllinger & von Müller, 2017). Therefore, with respect to the relationship between intuition and insight, the classification of intuitive or non-intuitive processes is always a matter of degree (Hogarth, 2010).

CHAPTER 2: FROM EARLY THEORIES TO CURRENT PERSPECTIVES

This chapter is based on the following manuscript:

Löffler, C. S. (2025). Intuition and the unconscious mind: From early theories to current perspectives. *Manuscript submitted for publication*.

Please note that some formatting changes were made to fit the layout of this dissertation. The content of the manuscript remains unchanged.

Abstract

Throughout the history of psychology, perspectives on the nature and scope of intuitive cognition have been remarkably diverse. This article provides a comprehensive overview by presenting a chronological timeline of key theories and contributions to the study of intuition and unconscious mental functions in general. Organized from early psychological theories to contemporary perspectives, it outlines the origins of different accounts, examines their underlying premises, and evaluates their impact on subsequent research and the overarching field of psychology.

Keywords: intuition, unconscious, automatic, heuristics

2.1 Introduction

The concept of intuition as an immediate form of knowledge is deeply rooted in Western intellectual history (Betsch, 2008; Osbeck, 2001; Van de Pitte, 1988). While it has its origins in spiritual and philosophical traditions, the scientific exploration of intuition gained considerable attention with the advent of modern psychology, where it has remained a prominent subject of research to the present day.

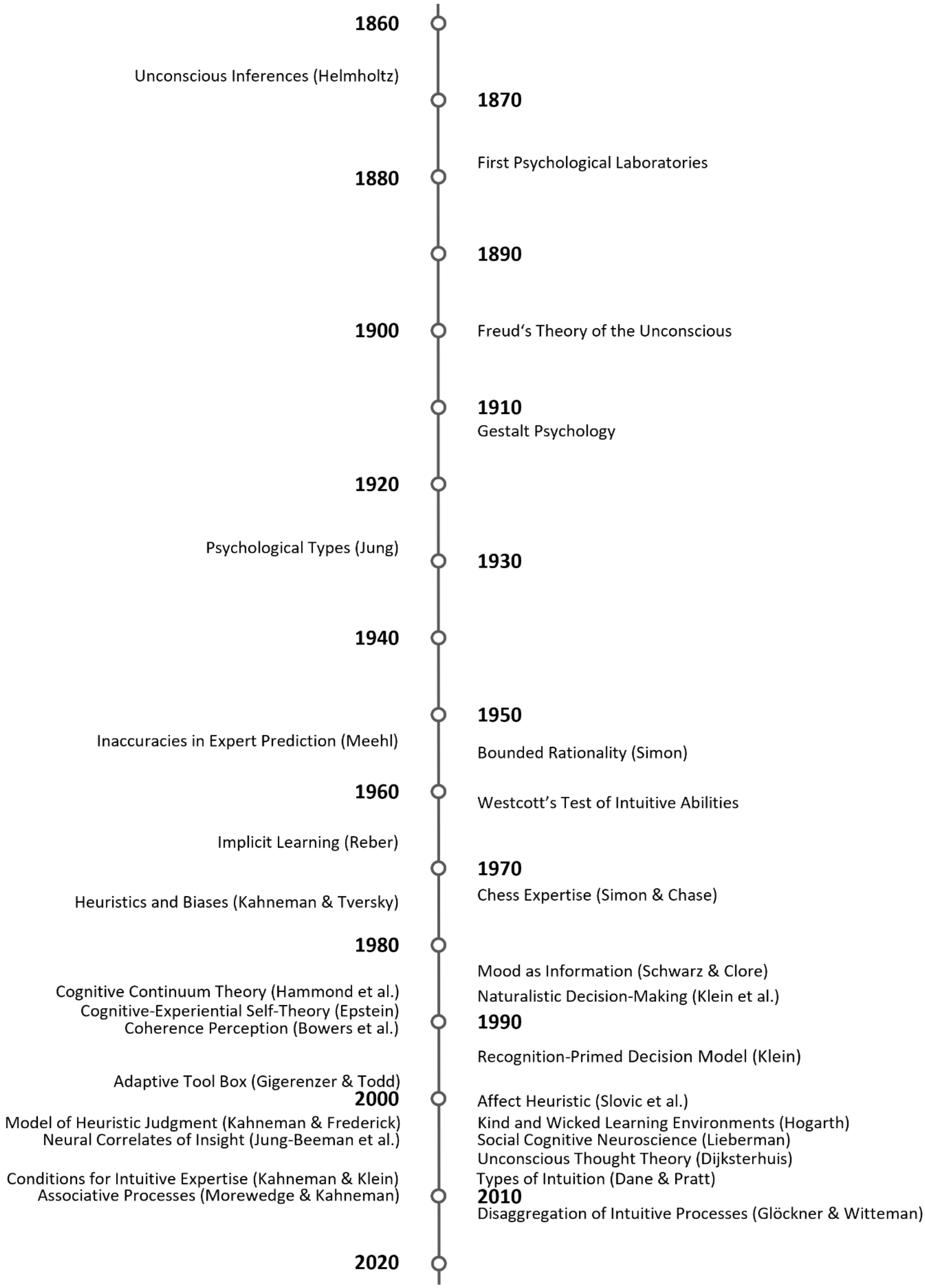
Nevertheless, throughout the history of psychology, perspectives on the nature and scope of intuitive cognition have been remarkably diverse. Some authors have described intuition as an almost mystical mode of understanding (e.g., Jung, 1928/1998; Vaughan, 1979). Some have suggested that intuition can perceive relationships that remain hidden from conscious experience (e.g., Bowers et al., 1990; Dijksterhuis, 2004; Kihlstrom, 1987; Klein, 1993; Reber, 1989; Simon & Chase, 1973). Others have linked the term to cognitive shortcuts (e.g., Denes-Raj & Epstein, 1994; Gigerenzer & Todd, 1999; Kahneman & Frederick, 2002), with some even associating these shortcuts with systematically biased judgments (e.g., Gilovich & Griffin, 2002; Tversky & Kahneman, 1974).

Considering the broad range of theoretical interpretations and empirical findings, this article seeks to provide a historical review on intuition and its various conceptualizations in psychology. In this respect, it will trace the historical development of various accounts by presenting a chronological timeline of major theories and contributions to the study of intuition and unconscious mental functions in general (for a visual timeline of selected theories and key ideas, see Figure 2.1).

As these concepts are closely linked to the broader history of psychology, the article begins with the foundational developments in psychology in the late 19th century and follows the progression of ideas over time (for further historical and philosophical perspectives on intuition and the unconscious mind, see Akinci & Sadler-Smith, 2012; Frankish & Evans, 2009; Hogarth, 2010; Osbeck, 2001; Uleman, 2005).

Figure 2.1

Chronology of major theories and key ideas in the study of intuition and the unconscious mind



2.2 The Beginnings of Modern Psychology (1870s onwards)

In the early stages of modern psychology in the late 19th century, the discipline was primarily concerned with establishing itself as an empirical science. This period marked the birth of psychology as an experimental discipline, with the establishment of the first psychological laboratories and the introduction of theories and methodologies aimed at understanding the internal workings of the mind (Kihlstrom, 1987; Uleman, 2005).

2.2.1 Introspectionism

Central to these early investigations was the study of consciousness (Frankish & Evans, 2009; Kihlstrom, 1987). Pioneers such as Wilhelm Wundt and Edward Titchener, who established the earliest psychological laboratories, were driven by the idea that the human mind was capable of observing its own internal processes (Frankish & Evans, 2009; Uleman, 2005). Their method of inquiry was *introspection*, by which participants were instructed to examine their own mental processes and break them down into objective sensations, images, and feelings (Frankish & Evans, 2009; Kihlstrom, 1987).

Early investigations in both laboratory and clinical settings, however, soon revealed that mental processes extend beyond conscious experience (Uleman, 2005). In this respect, for instance, Hermann von Helmholtz suggested that conscious perception is influenced by *unconscious inferences*, which are shaped by an individual's prior knowledge and past experiences (Frankish & Evans, 2009; Helmholtz, 1867; Kihlstrom, 1987; Turner, 1977).

2.2.2 Freud's Theory of the Unconscious

At the onset of the 20th century, Sigmund Freud formalized an idea that had already found expression in the literature and drama of the 19th century, notably in the works of Dostoyevsky: the idea of an unconscious mind driving human behavior (Evans, 2008; Uleman, 2005). Of course, the unconscious was not Freud's original idea; the concept of unconscious processes had already been implied by ancient Greek philosophers and had persisted in philosophical discourse almost ever since (Osbeck, 2001; Uleman, 2005). Nevertheless, Freud's significant contribution was to collect, elaborate, and refine these ideas, aiming to construct a scientific framework for understanding unconscious processes. In doing so, he not only introduced the concept of the unconscious into intellectual and cultural discourse but also popularized the term itself, leading to its widespread recognition in the following decades (Uleman, 2005).

Although Freud acknowledged the existence of a conscious mode of reasoning (which he referred to as *secondary process*), he proposed that the fundamental framework for conscious processes was to be found within the unconscious mind (whose processes he referred to as *primary process*, cf. Freud, 1900/1983). Freud's conceptualization of the unconscious was a domain of repressed desires, instincts, and unresolved conflicts. According to Freud, it was in this hidden part of the mind that an individual's deepest fears, motivations, and impulses were contained, constantly interfering with conscious thoughts and behavior (Epstein, 1994; Uleman, 2005).

Freud's pioneering concept of the unconscious not only challenged conventional notions of psychopathological symptoms and deviant behavior but also paved the way for further explorations into the inner workings of the mind (Epstein, 1994). As Epstein (1994, p. 709) has put it: "It was now possible to understand the pervasive irrationality of human beings, despite their capacity for rational thinking, as a natural outcome of the properties of the unconscious mind.".

2.2.3 Jung's Psychological Types

While Freud primarily emphasized the role of repressed sexual desires and inner conflicts as driving forces of human behavior, Carl Gustav Jung expanded Freud's perspective. In particular, he incorporated a wider range of psychological processes and stressed the importance of individual differences. Further, while Freud advocated careful observation and intellectual processing as the only means of acquiring knowledge (Raymond, 1982), Jung suggested various forms of knowledge acquisition (Akinci & Sadler-Smith, 2012; Hill, 1987). Embedded in his personality theory, Jung introduced the cognitive function of *intuition* as a complementary mode of understanding, which he described as "perception by way of the unconscious, or the perception of an unconscious content" (Jung, 1928/1998, p. 34). Jung's personality dimension of intuition encompassed a non-linear and holistic form of implicit cognition, enabling individuals to perceive hidden patterns and associations, without being able to explain the origins of these hunches (cf. Jung, 1928/1998).

Unlike Freud, who assumed that the unconscious was a subjective phenomenon, Jung proposed a dual nature of the unconscious that involved both personal and collective aspects (Hill, 1987). According to Jung, it was through intuition that individuals could access not only their personal but also the *collective unconscious*—an inherited reservoir of archetypes and symbolic knowledge that transcended individual experience (Hill, 1987; Westcott, 1968).

2.2.4 Gestalt Psychology

While Freud, Jung, and other pioneers established the foundations of depth psychology, another psychological tradition emerged in the early 20th century. This movement of *Gestalt psychology* emphasized a holistic understanding of human perception and cognition (Frankish & Evans, 2009).

Accordingly, Gestalt theorists such as Max Wertheimer, Kurt Koffka, and Wolfgang Köhler argued that the whole is not just the sum of its parts, but more than that. Thus, rather than considering perception as a mere aggregation of sensory impressions, they proposed that perception involves the processing of entire patterns and configurations (Frankish & Evans, 2009; Wagemans et al., 2012). In this regard, Gestalt theorists assumed that the mind is capable of organizing information into meaningful wholes, even though the underlying patterns and configurations are not consciously perceived.

Beginning with the study of perception, Gestalt theorists soon also directed their inquiry toward the study of problem-solving (Frankish & Evans, 2009). Based on the premises of Gestalt theory, for instance, Köhler (1925) and Wertheimer (1945/2020) suggested that problem-solving involves the implicit reorganization of information into a cohesive whole—thus, laying the foundation for later theories of sophisticated unconscious information processing (e.g., Bowers et al., 1990; Dijksterhuis & Nordgren, 2006).

2.2.5 Behaviorism: The Mind as Epiphenomenon

While the theories emerging from depth psychology and gestaltism were groundbreaking at the time, they also had some major weaknesses. In particular, the difficulty of articulating empirically testable predictions, and thus, the unfalsifiability of the theories drew substantial criticism in academic circles (Uleman, 2005; Wagemans et al., 2012).

Building on earlier research of the 19th century and in response to the limitations of introspectionism, depth psychology, and gestaltism, a new psychological tradition emerged during the early 20th century (Moore, 2011; Uleman, 2005). This tradition of *behaviorism* sought to establish a more objective and observable approach to understanding human behavior. Specifically, it focused exclusively on the relationship between environmental stimuli and behavioral responses (Frankish & Evans, 2009; Moore, 2011).

Many proponents of radical behaviorism assumed that an objective analysis of internal processes was not feasible. Thus, they argued that the mind and its contents should be treated as epiphenomena with little relevance to behavior (Kihlstrom, 1987; Uleman, 2005). In light of this perspective, it is not surprising that theories of the unconscious were not particularly valued by researchers during this period (Hogarth, 2010).

However, the limitations of behaviorism in explaining complex behaviors and innate abilities were already under criticism at the time (see e.g., Chomsky, 1959; Tolman, 1922).

Beginning in the 1950s, psychology gradually transitioned from its dominant behaviorist framework to a more cognitive perspective, reigniting interest in the unconscious (Kihlstrom, 1987).

2.3 The Cognitive Revolution (1950s onwards)

The transition from behaviorism to cognitivism (often referred to as the *cognitive revolution)* in the mid-20th century brought a fundamental shift toward the study of mental processes and their underlying mechanisms (Kaufmann, 2011; Kihlstrom, 1987; Simon, 1992). Initiated by this new development, the conception of the unconscious, previously shaped by psychodynamic theories, was slowly transformed into an unconscious capable of performing various functions (Kaufmann, 2011; Wilson, 2004). There are several works from this early cognitive period that left a lasting impact on subsequent research.

2.3.1 The Shortcomings of Expert Prediction

One of these landmark studies is the work of Paul Meehl (1954) on the shortcomings of expert clinical prediction (Hogarth, 2010; Kahneman & Klein, 2009). Meehl's (1954) contribution was to document that statistical decision rules were often superior to expert's clinical intuition (i.e., their intuitively derived judgments) in diagnostic tasks. This finding illustrated that the intuitive judgments of experts were not necessarily based on statistical considerations but on rather nonsystematic processes (Kahneman & Klein, 2009; Osbeck, 2001). In this regard, Meehl laid the groundwork for later advances in the field by documenting the fallibility of implicit thought processes (e.g., Gilovich & Griffin, 2002; Kahneman & Klein, 2009; Tversky & Kahneman, 1974). The subsequent discovery of related phenomena, such as illusory correlation (Chapman & Chapman, 1967), further substantiated the notion that implicit cognitive processes could be misguided in systematic ways (Hogarth, 2010).

2.3.2 Bounded Rationality

During the same period, Herbert Simon (1955) put forth the idea that human decision-making is *bounded* in its *rationality.* In essence, Simon proposed that the rationality of humans is limited because they lack the capacity to process larger amounts of information (Akinci & Sadler-Smith, 2012; Hogarth, 2010). This idea perfectly resonates with the Zeitgeist of the cognitive revolution, in which the mind was frequently depicted as a computer with limited computational capacity (Hogarth, 2010).

Due to this limited capacity, Simon (1955) suggested that individuals rely on simplified decision rules to selectively process only a fraction of the information available to them. In other words, shortcuts to analytical reasoning that yield satisfactory rather than optimal decisions (Akinci & Sadler-Smith, 2012; Hogarth, 2010). Simon's idea had a profound and lasting influence, significantly shaping the work of subsequent researchers who today commonly refer to these decision rules as *heuristics* (e.g., Gigerenzer & Gaissmaier, 2011; Tversky & Kahneman, 1974).

Notably, although Simon (1955) emphasized the capacity constraints in human information processing, he did not dismiss the possibility that the unconscious mind might be capable of making superior decisions than the conscious mind (Akinci & Sadler-Smith, 2012). In their later work, Simon and Chase (1973) explored the cognitive processes underlying implicit judgments in the context of chess expertise. They found that chess masters were able to *intuitively* identify good moves without having to engage in exhaustive reasoning (Akinci & Sadler-Smith, 2012; Kahneman & Klein, 2009). Based on these findings, Simon and Chase (1973) concluded that intuition is based on the recognition of patterns stored in memory. As later stated by Simon, intuitive judgments are "analyses frozen into habit and the capacity for rapid response through recognition" (Simon, 1987, p. 63).

2.3.3 Individual Differences in Intuitive Abilities

During the same era, while not as widely recognized today, Malcolm Westcott made noteworthy contributions to the study of implicit problem-solving. In 1961, he pioneered the first performance-based method for evaluating individual differences in intuitive abilities (Pretz & Totz, 2007; Shirley & Langan-Fox, 1996). During the subsequent years, *Westcott's Test of Intuitive Abilities* (Westcott, 1961) was widely used to explore the factors associated with intuitive performance (for a review, see Shirley & Langan-Fox, 1996), making intuition a phenomenon of interest to differential psychology as well (e.g., Baumann & Kuhl, 2002; Fallik & Eliot, 1985; Kaufman, 2011; Langan-Fox & Shirley, 2003; Westcott & Ranzoni, 1963).

Westcott's psychometric measure challenged participants to solve visual puzzles using minimal cues. In line with this, Westcott conceptualized intuition as the capacity to derive accurate judgments from limited information. Drawing on a similar premise as Simon and Chase (1973), he assumed that intuition was the result of prior analytic processes that had become automated through practice (Pretz & Totz, 2007; Westcott, 1961).

2.3.4 Implicit Learning

While for Westcott, Simon, and Chase, intuitive judgments were formed based on deliberate processes and explicit knowledge, this notion was challenged by the work of Arthur Reber. Starting in the 1960s, Reber demonstrated that individuals could effectively learn and recognize complex patterns through implicit processes, even without an explicit understanding of the rules underlying those patterns (Frankish & Evans, 2009).

He suggested that knowledge acquisition involved not only explicit but also implicit components that operate largely independently of explicit functions and often without explicit awareness of the acquired knowledge (Reber, 1993, p. 5). Reber's pioneering research on *implicit learning* (see e.g., Reber, 1967, 1976, 1989) had a profound impact on the field, as it offered an alternative perspective to the widely held notion that knowledge acquisition relied solely on explicit cognitive functions. His findings illustrated how people could possess knowledge and skills without having explicitly acquired them.

In the course of his research, Reber was also among the first to coin the concept of a *cognitive unconscious* (see also Kihlstrom, 1987; Piaget, 1973), which refers to the idea that complex information processing can occur without conscious awareness (Evans, 2008; Frankish & Evans, 2009). Within this theoretical framework, he characterized intuition as a common mental state or process that is the end product of implicit learning (Reber, 1989).

2.4 The Heuristics-and-Biases Program and its Sceptics (1970s onwards)

With the emergence of cognitive research during the mid-20th century, not only the great potential of intuitive cognition but also its susceptibility to bias had initially been documented. Building on the empirical foundations laid by earlier researchers, many research programs emerged from the 1970s to the 1990s, with one in particular leaving a lasting impression. In the late 1960s and early 1970s, Daniel Kahneman and Amos Tversky began to explore systematic biases in judgments under uncertainty. Their findings had a long-lasting impact on the conception of implicit cognitive processes but were also met with skepticism (Akinci & Sadler-Smith, 2012; Gilovich & Griffin, 2002).

2.4.1 Heuristics-and Biases

Building on the earlier work of Meehl (1954) and Simon (1955), the central idea of the *heuristics-and-biases* program was that decisions under uncertainty are often based on a limited set of simplified heuristic rules rather than on probabilistic reasoning (Gilovich & Griffin, 2002; Kahneman & Klein, 2009). As stated by Tversky and Kahneman (1974), these cognitive shortcuts operate with remarkable speed and are usually effective, but their reliance on data of limited validity makes them susceptible to systematic biases. Accordingly, Kahneman (2002) defined intuition as "thoughts and preferences that come to mind quickly and without much reflection" (p. 449), operating on the basis of simple reasoning heuristics, such as representativeness, availability, and anchoring.

The findings of the heuristics-and-biases program had major implications on various areas of research, as they illustrated that human judgment and decision-making can *systematically* deviate from the principles of rationality and Bayesian reasoning (Akinci & Sadler-Smith, 2012; Gilovich & Griffin, 2002; Kozyreva & Hertwig, 2021). However, while the heuristics-and-biases program provided valuable insights into the limitations of intuitive processes, it also contributed to the notion that intuition was inherently biased (Hogarth, 2010; Bowers et al., 1990). Although Tversky and Kahneman (1974) acknowledged that heuristics could yield both successful and unsuccessful outcomes, their work was typically interpreted as evidence for the computational deficiencies of individuals and the fallibility of human reasoning (Akinci & Sadler-Smith, 2012). Especially, the (presumed) notion that decision makers automatically relied on a few general heuristics led to dissatisfaction among some researchers (e.g., Gigerenzer, 1991; Gilovich & Griffin, 2002; Hogarth, 1981).

2.4.2 Quasi-Rationality

A less pessimistic perspective on implicit cognitive processes was advocated by researchers within a neo-Brunswikian tradition (e.g., Brehmer, 1994; Doherty & Kurz, 1996; Gigerenzer et al., 1991; Hammond et al., 1987; Hoffman et al., 1968). Contrary to Tversky and Kahneman (1974), Kenneth Hammond assumed that (implicit) judgments generally involve a weighted synthesis of information (e.g., Hammond, 1955; Hammond et al., 1964). In other words, a holistic integration of cues into an overall judgment.

Building upon Egon Brunswik's (1952) *theory of probabilistic functionalism*, Hammond et al. (1987) suggested that *quasi-rationality* (see also Brunswick, 1952) represents a middle ground on a cognitive continuum between intuitive and analytical thinking (see *cognitive continuum theory*; Hammond et al., 1987). Therefore, according to Hammond et al. (1987), most judgments are neither intuitive nor analytical, but something in between—they are quasi-rational.

When comparing the efficiency of analytical, quasi-rational, and intuitive judgments, Hammond et al. (1987) found that intuitive and quasi-rational cognition frequently outperformed analytical cognition. Additionally, they observed that analytical cognition was more prone to extreme errors. Crucially, Hammond et al. (1987) found that judgments were most accurate when the employed judgment strategy (i.e., analytical, quasi-rational, or intuitive) matched the requirements of the given task.

Thus, Hammond and his collaborators argued that it was not the fundamental dynamics of the human mind that led to biased intuitive judgments (see Tversky and Kahneman, 1974), but a mismatch between task characteristics and cognitive strategies. Accordingly, while the heuristics-and-biases approach favored a skeptical attitude toward implicit thought and reasoning processes, Hammond established a research tradition that emphasized the potential of these processes (Dhami & Mumpower, 2018).

2.4.3 The Adaptive Decision Maker

Similar to Hammond, Gerd Gigerenzer questioned the applicability of Kahneman and Tversky's findings to real-world decision-making scenarios. As a prominent critic of the heuristics-and-biases program, he advocated for a more nuanced understanding of heuristic decision processes (e.g., Gigerenzer, 1991; Gigerenzer, 1996; Gigerenzer & Todd, 1999).

Much like the heuristics-and-biases program, Gigerenzer's perspective was rooted in Simon's (1955) concept of bounded rationality, assuming that decision-making is a product of satisficing rather than optimizing. However, contrary to the heuristics-and-biases program, Gigerenzer emphasized the adaptive nature of heuristics, arguing that they can lead to highly effective decisions in environments the human mind is naturally suited to (e.g., Gigerenzer, 1991; Gigerenzer et al., 1991; Gigerenzer & Hoffrage, 1995; Gigerenzer & Todd, 1999).

From the 1990s onwards, Gigerenzer significantly influenced the field with his adaptive decision-maker perspective (Betsch & Glöckner, 2010; Gigerenzer & Todd, 1999; see also Payne et al., 1988). According to this perspective, heuristics are domain-specific adaptive reasoning tools that enable quick and effective decision-making in situations characterized by uncertainty, limited information, and time constraints (e.g., Gigerenzer, 2001; Gigerenzer & Brighton, 2009; Gigerenzer & Todd, 1999). In this regard, Gigerenzer suggested that the human species has evolved various heuristic strategies (comparable to an *adaptive toolbox;* Gigerenzer & Todd, 1999; see also Gigerenzer, 2001; Gigerenzer, 2002) to efficiently navigate its environment. Accordingly, different heuristic strategies in this adaptive toolbox are assumed to differ in terms of processing effort and outcome accuracy. Thus, as suggested by Gigerenzer, individuals deliberately select their heuristic strategies depending on their environment and the task at hand (Gigerenzer, 2001; Gigerenzer & Todd, 1999).

Therefore, in contrast to the heuristics-and-biases program, Gigerenzer suggested that heuristics often rely on deliberate mechanisms and tend to yield satisfactory levels of accuracy across various real-world scenarios (Gigerenzer, 2001; Gigerenzer & Todd, 1999). In this regard, Gigerenzer's work established a more optimistic perspective on heuristic reasoning strategies and demonstrated their potential to generate effective judgments with limited data (Gigerenzer & Brighton, 2009).

2.4.4 Intuition as Coherence Perception

A further perspective on intuitive processes emerged from the work of Kenneth Bowers and his collaborators, who shaped a holistic Gestalt conception of intuition during the 1990s. Critically reflecting on the heuristics-and-biases program, Bowers and colleagues (1990, 1995) proposed to investigate intuition as a dynamic process of generating new ideas or hypotheses. Thus, they encouraged a more comprehensive understanding of intuitive processes rather than considering them as mere strategies for effort reduction and selective processing of information.

Based on their findings, Bowers et al. (1990) defined intuition as “preliminary perception of coherence (pattern, meaning, structure) that is at first not consciously represented, but which nevertheless guides thought (..) toward a hunch or hypothesis” (p. 74). Accordingly, Bowers et al. (1990) emphasized that intuition is not an immediate apprehension of truth (see Jung, 1928/1998) but a progressive process that gradually unfolds as information is processed. More specifically, they proposed that clues to coherence automatically initiate a *spread of activation* through mnemonic and semantic networks (see also Anderson, 1983; Collins & Loftus, 1975), producing an intuitive hunch that eventually becomes consciously experienced. Further, Bowers et al. (1990) proposed that this process could lead to sudden “Aha” experiences, thus, conceptualizing intuitive hunches as preliminary stage of insight (Bowers et al., 1990).

Accordingly, while heuristic approaches defined intuitive processes through effort reduction and selective processing of information (cf. Betsch & Glöckner, 2010), Bowers and his collaborators characterized intuition as a fundamental human capacity that effortlessly integrates diverse sources of information outside of awareness. Their pioneering work on coherence intuition has inspired numerous subsequent researchers (e.g., Balas et al., 2012; Bolte et al., 2003; Kounios et al., 2006; Löffler & Topolinski, 2023; Maldei et al., 2019; Remmers & Zander, 2018; Topolinski & Strack, 2009b; Zander et al., 2016).

2.4.5 Naturalistic Decision-Making

Another noteworthy contribution was made by researchers studying human decision-making in field settings (Akinci & Sadler-Smith, 2012; Kahneman & Klein, 2009). Gary Klein pioneered the field of *naturalistic decision making* (NDM) by exploring how individuals reach decisions in demanding, real-world situations. Specifically, he investigated how experienced professionals, such as firefighters, nurses, or military commanders, could successfully perform cognitively complex functions in situations characterized by high stakes, time pressure, and uncertain conditions (Klein, 1993). Accordingly, a key objective of Klein's research was to demystify more sophisticated intuitive processes by identifying the implicit cues that underlie expert judgments (Kahneman & Klein, 2009).

In accordance with Simon and Chase (1973), Klein suggested that intuition is based on accumulated experience. According to Klein's (1993) *recognition-primed decision model,* experts implicitly rely on their prior experiences to identify patterns that indicate the underlying dynamics of a situation (Akinci & Sadler-Smith, 2012; Glöckner & Witteman, 2010; Hogarth, 2010). Thus, as Klein (2003) has put it: "Intuition is the way we translate our experiences into judgments and decisions. It's the ability to make decisions using patterns to recognize what's going on in a situation and to recognize the typical action scripts with which to react." (p. 13).

Looking back at this period of research from the 1970s to the 1990s, it becomes apparent that a variety of perspectives on intuitive processes and their underlying mechanisms emerged during this time. Working in relative isolation from each other, several groups of researchers had systematically accumulated evidence and had each come to their own conclusions about the functions of the unconscious mind.

Based on Simon's (1955) theory of bounded rationality, the research groups around Kahneman and Gigerenzer had both established their own conception of intuition as a product of selective information processing. In other words, an implicit mechanism to cope with the computational limits of the human brain. However, although both assumed that heuristic information processing was inherent to human decision-making, their conclusions about the functionality of these cognitive shortcuts differed significantly (e.g., Gigerenzer, 1991; Gigerenzer & Todd, 1999; Kahneman, 2002; Tversky & Kahneman, 1974).

Diverging from the heuristic perspective, Bowers et al. (1990, 1995) and Klein (1993) posited that intuitive processes could effectively process large amounts of information, despite operating without conscious awareness. Both independently arrived at the conclusion that intuition was a more or less abstract form of pattern recognition based on previous experience. In a similar vein, Hammond and colleagues (1987) argued that intuitive cognition may have specific advantages over analytical cognition and presented evidence that analytical processes were even more susceptible to errors in practice. Remarkably, already by 1987, Hammond et al. expressed doubts about a clear distinction between intuitive and analytical cognition—an idea that in light of later developments appears very modern today.

Nevertheless, as diverse as the functions and processing potentials attributed to intuitive cognition were during that time, in retrospect there was a common limitation to all of these theories. Although the influence of subjective experiences accompanying human thinking had been sporadically discussed before (e.g., Janis & Mann, 1977; Schwarz & Clore, 1983; Simon, 1987; Zajonc, 1980), this aspect received only limited attention until the 1990s (Akinci & Sadler-Smith, 2012; Schwarz & Clore, 2003).

2.5 The Influence of Affect (1980s onwards)

After emotions had long been assumed to be a mere byproduct of thought, the 1990s marked a shift toward a greater interest in affective states and how they influenced cognitive processes (Akinci & Sadler-Smith, 2012; Peters et al., 2006). This *affective turn* extended across various research traditions (see e.g., Damasio, 1994; Kahneman & Frederick, 2002; Schwarz & Clore, 1983; Slovic et al., 2002), soon revealing the pervasive influence of affective states on various aspects of implicit cognition (e.g., Ashby et al., 1999; Bolte et al., 2003; Lufityanto et al., 2016; Schwarz et al., 1991; Topolinski & Strack, 2009b; Västfjäll et al., 2008). As a result, the question of how affective states influence implicit cognitive processes and the resulting judgement led to the development of various theories, including the *somatic marker hypothesis* (Damasio, 1994), the *mood as information theory* (Schwarz & Clore, 1983), the *cognitive tuning theory* (Schwarz, 2002), and the *affect heuristic* (Slovic et al., 2002). The latter three of these theories will be discussed in more detail below.

2.5.1 The Mood as Information Theory: Mood as Intuition

Among the pioneers exploring the influence of emotional states were Norbert Schwarz and Gerald Clore, who proposed the *mood as an information theory* as early as 1983 (Schwarz & Clore, 1983; for a review, see Schwarz, 2012). The central idea of this theory was that individuals implicitly rely on their current mood as a source of information when forming judgments. In other words, during the process of judgment formation, information that aligns with the current mood is particularly salient to an individual. As a result, according to the mood-as-information theory, a person in a positive mood is more likely to intuitively assess a situation or option favorably, whereas a negative mood may lead to a more pessimistic evaluation (Schwarz, 2012; Schwarz & Clore, 1983).

2.5.2 The Cognitive Tuning Theory: Mood as a Moderator of Cognitive Processing

Further, Schwarz (1991; see also Schwarz, 2002; Schwarz & Bless, 1991) proposed that emotional states influence a person's spontaneously adopted reasoning style (which he referred to as *cognitive tuning*; cf. Schwarz, 2002). Accordingly, he suggested that positive moods encouraged an intuitive and creative processing of information, whereas negative moods led to a more systematic and thorough processing. Building upon Schwarz's (2002) work, this hypothesis found resonance among diverse researchers who further substantiated it through empirical investigations (e.g., Baumann & Kuhl, 2002; Bless et al., 1990; Bolte et al., 2003; Bolte & Goschke, 2010; Isen et al., 1987; Sinclair & Mark, 1995; Storbeck & Clore, 2005).

2.5.3 The Affect Heuristic: Affective Reactions as Intuition

A further affect-as-intuition theory, the *affect heuristic*, was introduced by Paul Slovic and his collaborators (2002) in the context of the heuristics-and-biases approach. Contrary to the cognitive tuning theory (Schwarz, 1990, 2002), which describes how mood states can moderate cognitive processes, and the mood as information theory (Schwarz & Clore, 1983), which addresses the misattribution of affective states as a mediating factor, the affect heuristic offers a distinct framework. Specifically, it explains how direct emotional reactions to a stimulus are incorporated into judgments.

In this regard, Slovic et al. (2002) proposed that individuals tend to rely on their emotional reactions to objects and events when evaluating potential outcomes. In other words, that individuals form their evaluations not based on rational considerations but are guided by their emotional responses toward them. Accordingly, a person might perceive a certain activity as safe if it evokes positive emotions, even if a more rational analysis might suggest otherwise—a heuristic decision strategy (Alhakami & Slovic, 1994; Slovic et al., 2002).

In hindsight, it may be surprising that the influence of affect was not integrated into the theoretical framework of the heuristics-and-biases approach earlier. However, as Kahneman and Frederick (2002) note, “the failure to identify [the influence of affect] earlier reflects the narrowly cognitive focus that characterized psychology for some decades” (p. 56).

2.6 Dual-Process Theories (1990s onwards)

Another important development during the 1990s and early 2000s was the increasing prevalence of dual-process theories (for reviews, see Chaiken & Trope, 1999; Evans, 2008). Although this dualistic conception of the mind was far from new (consider, for example, Freud’s distinction between primary and secondary process; see Frankish & Evans, 2009, for a review of historical dual-process models), dual-process theories gained considerable prominence during that time and were widely embraced within the field.

Accordingly, various forms of dual-process theories have been suggested. However, all assume a distinction between cognitive processes that are rapid, automatic, and unconscious, and processes that are slow, controlled, and conscious (cf. Evans, 2009). Different theorists have, for example, referred to those coexisting processing modes as *System 1* vs. *System 2* (Evans, 2008; Kahneman, 2011; Kahneman & Frederick, 2002), *associative* vs. *rule-based* (Sloman, 1996), *impulsive* vs. *reflective* (Strack & Deutsch, 2004), or *experiential* vs. *rational* (Epstein, 1990).

While the distinction between two cognitive systems is shared across all dual-process theories, there are also differences. In this regard, dual-process theories diverge, for example, in how (or whether) the two systems interact, the processing capacities attributed to the unconscious system, or whether the unconscious system is intertwined with affect (Evans, 2008; Kaufmann, 2011). Given the abundance of dual-process models, a review of all influential theories would go far beyond the scope of this work. Therefore, in the upcoming sections, three influential dual-process theories will be presented to exemplify the similarities and differences among various models.

2.6.1 The Cognitive-Experiential Self-Theory

Seymour Epstein's *Cognitive-Experiential Self-Theory* (CEST, 1990) played an important role in intuition research due to its emphasis on affect (Akinci & Sadler-Smith, 2012; Frankish & Evans, 2009). His dual-process theory combined the Freudian idea of primary (unconscious) and secondary (conscious) processes with cognitive theories of the unconscious mind (Frankish & Evans, 2009).

According to this global theory of personality, there are two independent systems by which a person experiences the world: one that rapidly processes information based on past experiences and emotions (called the intuitive-experiential system) and another that is deliberate, abstract, and analytical (called the analytic-rational system; Epstein, 1990, 1994).

As a psychodynamic theory, CEST proposes that the interaction of these two parallel systems determines a person's thinking and behavior. The relative dominance of one system over the other is influenced by a variety of factors, including the situational context or a person's individual preference for intuitive or analytical processing. Further, according to Epstein (1994), emotional arousal can shift the balance in favor of the experiential system (Epstein, 1994). Thus, in a state of increased emotional arousal, such as anxiousness or excitement, CEST suggests that an individual may rather rely on the quick, emotion-driven responses of the intuitive-experiential system than on deliberate reasoning.

2.6.2 The Model of Heuristic Judgment

Another and probably the best-known dual-process model was presented by Kahneman and Frederick (2002; see also Kahneman, 2011). According to this model, there are two cognitive systems, each comprising its own set of cognitive operations. The cognitive operations of System 1 are characterized by fast, automatic, and associative processing of information. Since this information is processed according to heuristic rules, System 1 processes operate with minimal effort and quickly generate intuitive responses, but they are also susceptible to systematic biases. In contrast, the cognitive operations of System 2 are controlled and deductive, requiring more time and processing effort. Although Kahneman and Frederick (2002) note that System 1 is more primitive than System 2, this does not necessarily make it less capable. Through practice, the complex cognitive operations of System 2 are adopted by System 1 as they become automated. This, once again, highlights Kahneman's perspective on intuitive processes—they are useful shortcuts to analytical cognition but do not lead to independent or original insights.

While most dual-process theories propose parallel activation of both systems, potentially leading to competing judgments (e.g., Epstein, 1990; Reber, 1993; Sloman, 1996), Kahneman and Frederick's (2002) model assumes a *default-interventionist* interaction between System 1 and System 2 (cf. Evans, 2008). According to this framework, System 1 automatically generates an intuitive (i.e., heuristic) response that is then confirmed, corrected, or overridden by System 2 (Kahneman & Frederick, 2002; see also Morewedge & Kahneman, 2010).

2.6.2.1 Associative Mechanisms of System 1

In their 2010 article, Morewedge and Kahneman extended this theory based on more recent findings from the field. Assuming that System 1 is equivalent to the implicit operations of associative memory, they proposed three general mechanisms of System 1 that underly heuristic bias: *associative coherence*, *attribute substitution*, and *processing fluency*.

In short, associative coherence refers to the idea that the way information is processed by System 1 triggers a self-reinforcing activation between compatible ideas (e.g., Levy & Anderson, 2002; Neely, 1977; Song & Schwarz, 2008). According to Morewedge and Kahneman (2010), this leads to a coherent but not necessarily accurate interpretation, and thus, can result in certain heuristic biases.

The second associative mechanism Morewedge and Kahneman (2010) suggest to underly the biases of System 1 is attribute substitution. This refers to the tendency to replace an attribute that is cognitively complex to evaluate with a more easily accessible one. Thus, if a problem is more difficult to evaluate than one of the problems it associatively evokes, System 1 tends to automatically replace the answer for the difficult problem with the easier one instead (cf. Morewedge & Kahneman, 2010; see also Kahneman & Frederick, 2002). Put simply, "when confronted with a difficult question people often answer an easier one instead, usually without being aware of the substitution." (Kahneman & Frederick, 2002, p. 4).

The third mechanism outlined by Morewedge & Kahneman (2010), illustrates how *processing fluency* (i.e., the subjective experience of ease in processing information) can lead to imperfect System 1 judgments. Accordingly, research has shown that information processed with ease is typically perceived more positively, such as being deemed more true or familiar, compared to information that is processed with difficulty (e.g., Reber et al., 1998; Topolinski & Strack, 2009b; Unkelbach, 2007, for reviews, see Alter & Oppenheimer, 2009; Schwarz, 2004). Thus, as Morewedge and Kahneman (2010) conclude, although high processing fluency may induce feelings of confidence, it is a poor indicator of judgment accuracy. This is because it often arises from judgment-irrelevant factors such as a positive mood or the visual clarity of the font in which a statement is presented (e.g., Bless et al., 1990; Bolte et al., 2003; Reber & Schwarz, 1999; Unkelbach, 2007). Further studies even indicate that high processing fluency and the positive affect it elicits (see Reber et al., 1998; see also Winkielman et al., 2003; Winkielman & Cacioppo, 2001) have the potential to reverse intuitive judgments (Topolinski & Strack, 2009a, 2009b).

Within a broader context, the three associative mechanisms outlined by Morewedge and Kahneman (2010) illustrate the weaknesses of System 1 processes within their suggested dual-process model. Nevertheless, their account also illustrates their perspective on the remarkable ability of System 1 to react quickly and efficiently to occurring challenges—often generating associatively related responses. However, given that these efficient mechanisms are susceptible to bias, the monitoring and correcting functions of System 2 are crucial to ensure the accuracy of judgments (Kahneman & Frederick, 2002; Morewedge & Kahneman, 2010).

2.6.3 The Unconscious Thought Theory

Another dual-process model with rather unconventional implications was proposed by Ap Dijksterhuis and Loran Nordgren. Following the general distinction of dual-process theories, the *Unconscious Thought Theory* (UTT, Dijksterhuis, 2004; Dijksterhuis & Nordgren, 2006) posits that there are two modes of thought, one conscious and one unconscious. As outlined by Dijksterhuis and Nordgren (2006), the main difference between these modes of thought is that "conscious thought is thought with attention; unconscious thought is thought without attention (or with attention directed elsewhere)." (p. 96). The UTT further suggests that conscious thought is constrained in its capacity to process information, and thus may only lead to better judgments when a minimal amount of information is available. In contrast, unconscious thought follows a bottom-up principle and can integrate large amounts of information into overall judgments (Dijksterhuis & Nordgren, 2006). This conceptualization runs counter to most perspectives on conscious and unconscious processes (e.g., Epstein, 1990; Gigerenzer & Todd, 1999; Kahneman & Frederick, 2002), as UTT characterizes conscious thought processes as being prone to bias. Thus, while most dual-process theories assign complex cognitive operations to the conscious system, Dijksterhuis and Nordgren (2006) posit that complex judgments are best approached through unconscious processes.

Accordingly, participants in Dijksterhuis and his collaborators' experiments were found to make significantly better judgments when initially presented with a (complex) problem and subsequently distracted to allow unconscious processing (e.g., Dijksterhuis, 2004; Dijksterhuis et al., 2006; Dijksterhuis & Meurs, 2006). This finding suggests that a period of incubation, such as a night's sleep, may indeed improve decisions more effectively than engaging in conscious deliberation (Dijksterhuis & Nordgren, 2006; Hogarth, 2010). Nevertheless, doubts have been raised by other researchers regarding this finding and the boundary conditions of Dijksterhuis' approach (e.g., Acker, 2008; Custers, 2014; Hogarth, 2010; Newell et al., 2009; Payne et al., 2008).

2.7 Neural Correlates of Intuition (2000s onwards)

In addition to the growing popularity of dual-process theories, researchers in the early 2000s saw great promise in the new technologies emerging from the field of neuroscience. Accordingly, various researchers utilized the opportunities arising with functional magnetic resonance imaging (fMRI) to explore the neural substrates of implicit cognitive processes (e.g., Dehaene et al., 2006; Jung-Beeman et al., 2004; Kounios et al., 2006; Lieberman, 2000; Lieberman et al., 2004; Yang & Shadlen).

2.7.1 The Cognitive Neuroscience of Insight

For instance, Beeman, Kounios, and their collaborators made important contributions by examining patterns of neural activity during insight problem-solving (e.g., Bowden & Jung-Beeman, 2003a; Jung-Beeman et al., 2004; Kounios et al., 2006; Kounios & Beeman, 2014). They found that sudden insights ("Aha" experiences) into the solution of verbal puzzles were associated with different neural activity in the right hemisphere than non-insight solutions (Jung-Beeman et al., 2004). In addition, they observed that the same region was already active before the "Aha" experience, indicating that the solution to a problem was already weakly activated during the early stages of problem-solving. Based on this finding, Jung-Beeman and colleagues (2004) concluded that insight problem-solving involves initial unconscious processes followed by a sudden moment of insight. Remarkably, this observation is consistent with the intuition-insight continuum earlier proposed by Bowers et al. (1990).

2.7.2 Neural Foundations of Explicit and Implicit Processes

In addition to Beeman et al.'s research on the neural mechanisms of insight, there was a wave of optimism in the early 2000s regarding the social cognitive neuroscience approach of Lieberman and his collaborators (Lieberman, 2000; Lieberman, 2007; Lieberman et al., 2002; Lieberman et al., 2004; Satpute & Lieberman, 2006). Various authors commented positively on Lieberman's work, considering his early findings as a potential milestone for dual-process theories (e.g., Dane & Pratt, 2009; Evans, 2008; Glöckner & Witteman, 2010).

Specifically, Lieberman and colleagues proposed the existence of two distinct neurological systems: A reflective system, referred to as *C-system*, and a reflexive system, referred to as *X-system*. They observed that activation of the C-system involved brain areas associated with explicit learning and propositional thought. In contrast, activation of the X-system was associated with a network of neural structures involved in associative learning and automatic social cognition (Lieberman, 2007; Lieberman et al., 2004; Satpute & Lieberman, 2006). Based on these findings, Lieberman and his collaborators concluded that explicit (i.e., controlled) and implicit (i.e., automatic) cognition processes are associated with different patterns of brain activation. Further, consistent with the general assumption of dual-process theories, Satpute and Lieberman (2006) suggested that C-system processes are slow, abstract, and intentional, while X-system processes are rapid, automatic, and capable of parallel execution.

However, although Lieberman's findings were received with great enthusiasm, other neuroscientific studies did not support a common distinction in deliberate and intuitive processes (for a review, see Volz & von Cramon, 2008). Thus, as Volz and von Cramon (2008) conclude: "the approach to converge on the specific cognitive processes underlying intuitive decisions by means of neuroscientific results (…) was not continuative." (p. 82).

2.8 Conditions for Intuitive Accuracy (2000s onwards)

Apart from seeking to locate intuitive processes through imaging techniques, a central focus of research in the 2000s revolved around the question of when intuitive judgments can be trusted. This interest arose from the already widely established consensus among researchers that, while intuitive judgments can be highly accurate under certain conditions, they are also prone to errors (e.g., Evans, 2008; Glöckner & Witteman, 2010; Hogarth, 2010; Kahneman & Klein, 2009; Morewedge & Kahneman, 2010). Based on this common premise, a large body of work has been dedicated to identifying factors that lead to accurate or inaccurate intuitive inferences (e.g., Alter et al., 2007; Baumann & Kuhl, 2002; Bolte et al., 2003; Dijksterhuis, 2004; Gigerenzer & Gaissmaier, 2011; Gigerenzer & Todd, 1999; Lufityanto et al., 2016; Metcalfe et al., 1993; Morewedge & Kahneman, 2010; Schooler &

Hertwig, 2005; Topolinski & Strack, 2009b). Given the multitude of factors that have been shown to impact the accuracy of intuitive judgments, it would hardly be feasible to discuss all of them in this article (for reviews, see Dane & Pratt, 2007; Hogarth, 2010; Kahneman & Klein, 2009; Morewedge & Kahneman, 2010). Nevertheless, in the subsequent sections, three of the most influential theories regarding the conditions for intuitive accuracy will be outlined.

2.8.1 Learning Environments

Based on the almost universally accepted notion that intuition is the result of learning, Hogarth (2001) suggested that the accuracy of intuitive judgments is greatly influenced by the environment in which a learning experience occurs. According to Hogarth (2001, 2010), in *kind learning environments*, appropriate feedback is present, enabling individuals to have valid learning experiences. This allows them to draw accurate intuitive inferences from previously experienced situations when confronted with comparable scenarios. In other words, Hogarth (2001) argues that, when learning occurs in an environment with adequate feedback, individuals are more likely to make accurate intuitive inferences.

Contrarily, in *wicked learning environments*, feedback is either absent or distorted, and the sampled learning experiences do not accurately represent the situation in which the intuitive judgment is applied. Thus, as Hogarth (2010) notes: "whereas people might process the data they see in an appropriate manner, they lack the meta cognitive ability to correct for sampling biases and/or missing feedback" (p. 343). Consequently, intuitive judgments that arise under these conditions are more likely to be inaccurate.

Therefore, with respect to the trustworthiness of intuitive judgments, Hogarth (2001, 2010) suggests that accurate judgments can emerge when the contextual conditions allow for valid inferences from previous situations. However, if the situation's representativeness is uncertain or if inappropriate heuristic decision rules are applied, intuitive judgments are likely to be less accurate than judgments derived from analytic processing (cf. Hogarth, 2010).

2.8.2 Intuitive Expertise

In a similar vein, Kahneman and Klein (2009) attempted to define the boundary conditions distinguishing true intuitive expertise from biased or overly confident judgments. In accordance with Hogarth, they conclude that the trustworthiness of intuitive judgments depends on “the environment in which the judgment is made and of the opportunity that the judge has had to learn the regularities of that environment.” (Kahneman & Klein, 2009, p. 524). Thus, a crucial factor for the accuracy of intuitive judgments is the high validity of an environment. As Kahneman and Klein (2009) state, environments are of high validity when objectively observable cues reliably predict subsequent events (such as in firefighting or medicine). Thus, in high-validity environments, accurate intuitive inferences based on previously acquired expertise (i.e., tacit knowledge about relevant cues) can be achieved. Conversely, in low-validity environments (such as the stock market), outcomes always remain unpredictable to a certain degree, which makes it impossible to draw accurate intuitive conclusions, irrespective of one’s expertise. Thus, if the environment is of low validity, intuitive judgments are likely to rely on imperfect heuristic processes that lead to biased or overly confident judgments (Kahneman & Klein, 2009).

2.8.3 Ecological Rationality

Contrary to the classical notion that heuristics are associated with error-prone judgments, Gigerenzer and his collaborators argue that heuristic strategies may even be superior to analytical processes in complex environments. In their 2011 article, Gigerenzer and Gaissmaier discuss the counterintuitive phenomenon of *less-is-more-effects*, challenging the interpretation of heuristics as irrationally applied rules of thumb. As Gigerenzer and

Gaissmaier (2011) note, there is evidence that selectively ignoring part of the information can actually be beneficial in complex and uncertain environments.

A striking example of such a less-is-more-effect was, for instance, reported by Schooler and Hertwig (2005; see also e.g., Czerlinski et al., 1999; Gigerenzer & Goldstein, 1996). They found that forgetting some information (resulting in a reduced amount of information to integrate into the judgment) may even lead to more accurate heuristic inferences. In this respect, Gigerenzer and Gaissmaier (2011) suggest that "there is an inverse-U-shaped relation between level of accuracy and amount of information (…). In other words, there is a point where more is not better, but harmful." (p. 453). Accordingly, they argue that despite processing less information, heuristics have the potential to outperform more complex strategies. This especially applies when critical information is unknown or has to be estimated from small samples—a situation that is frequently found in real-world decision-making scenarios (Gigerenzer & Gaissmaier, 2011; Gigerenzer & Todd, 1999).

However, whether ignoring part of the information (i.e., using a heuristic strategy) leads to more accurate judgments than deliberate processing, crucially depends on the fit between the particular heuristic and the structure of the environment (as denoted by Gigerenzer as *ecological rationality*). Therefore, as Gigerenzer (2002) posits, the rationality of heuristics "is not logical but ecological" (p. 114). In other words, "a heuristic is ecologically rational to the degree that it is adapted to the structure of the environment" (Gigerenzer & Todd, 1999, p. 13). Thus, given that all heuristics are domain-specific, the accuracy of heuristic inferences depends on an individual's ability to select an appropriate (i.e., ecologically rational) heuristic for the situation at hand. In this respect, Gigerenzer and his collaborators also emphasize the crucial role of learning, as through sufficient experience, individuals learn to select ecologically rational strategies (Gigerenzer & Gaissmaier, 2011).

In summary, it is noteworthy that each of the theories presented converges on the conclusion that intuitive accuracy is determined by prior learning experiences and contextual conditions. In particular, Hogarth (2001) points out the role of different learning environments, but also notes that the learning experiences have to match the context in which an intuitive judgment is made. Similarly, Kahneman and Klein (2009) conclude that accurate intuitive inferences can only be made in certain (i.e., valid) environments and the individual must have acquired tacit knowledge about them. Gigerenzer and his collaborators draw a similar conclusion to that of Hammond and colleagues (1987). Specifically, that individuals must adapt their decision strategies to the requirements of the given context to make accurate inferences (Gigerenzer, 2002; Gigerenzer and Gaissmaier, 2011; Gigerenzer & Todd, 1999).

2.9 Dual-Process Theories Revisited: Distinguishing Intuitive Processes (2010s onwards)

While the theories discussed in the previous section are mainly concerned with heuristic decision-making, other researchers have rightly pointed out that heuristics do not explain the full scope of intuitive processes. In this respect, Betsch and Glöckner (2010) note that while prominent approaches frequently equate intuition with heuristic (i.e., selective) information processing (e.g., Gigerenzer & Brighton, 2009; Gilovich & Griffin, 2002; Kahneman & Frederick, 2002), there are also cases in which an extensive integration of information is observed. Correspondingly, there is convincing evidence to suggest that certain intuitive processes are indeed capable of holistically integrating large amounts of information in parallel (e.g., Betsch et al., 2001; Bowers et al., 1990; Glöckner & Betsch, 2008; Klein, 1993; Reber, 1989). This raises the important question of whether "intuition" can be understood as a construct or if the term serves as a broad label for a range of different cognitive phenomena (cf. Glöckner & Witteman, 2010).

Additionally, in recent discussions, a growing number of researchers have expressed doubts about the viability of the two-process perspective (e.g., Betsch & Glöckner, 2010; Evans, 2008; Hogarth, 2010; Kruglanski & Gigerenzer, 2011). In this regard, Hogarth (2010) notes that although the dual-process perspective has been useful in bridging different areas of psychological research, “there are further useful distinctions to be made within the two processes of dual models.” (p. 342). In a similar vein, Evans (2008) concludes that “(a) there are multiple kinds of implicit processes described by different theorists and (b) not all of the proposed attributes of the two kinds of processing can be sensibly mapped on to two systems as currently conceived.” (p. 255). Considering the heterogeneity of implicit processes commonly labeled as *intuitive*, thus, Hogarth (2010), argues that “the major challenge facing intuition research is the need for conceptual work to define the nature and scope of different intuitive phenomena.” (p. 338).

From a historical perspective, the idea of intuition as a non-unitary construct is not new (Akinci & Sadler-Smith, 2012). As early as 1979, Vaughan suggested to distinguish between different types of intuitive processes. Likewise, Epstein et al. (1996) speculated that there may be a range of different intuitive abilities. Further, drawing from Reber’s (1989, 1993) research on implicit learning, Hogarth (2001) suggested to discriminate between basic, primitive, and sophisticated types of intuitive cognition. In recent years, several further categorizations of intuitive processes have been proposed (see e.g., Dane & Pratt, 2009; Glöckner & Witteman, 2010; Gore & Sadler-Smith, 2011; Pretz & Totz, 2007; Sobkow et al., 2018). Among these, in particular, the conceptualizations proposed by Dane and Pratt (2009) and Glöckner and Witteman (2010) have received positive recognition.

2.9.1 Problem-Solving, Moral, and Creative Intuition

Dane and Pratt (2009) suggest to distinguish between *problem-solving*, *moral*, and *creative* types of intuition. Problem-solving intuition refers to a quickly occurring pattern recognition and matching process. In this respect, the majority of intuitive processes discussed in cognitive psychology fit into this category (cf. Dane & Pratt, 2009), ranging from the intuitive judgments of chess masters (Simon & Chase, 1973) to the more basic heuristic processes proposed by Tversky and Kahneman (1974; see also Goldstein & Gigerenzer, 1999; Hogarth, 2001; Kahneman & Frederick, 2002; Klein, 1993; Lieberman, 2007; Reber, 1989; Westcott, 1961).

Moral intuition, the second type suggested by Dane and Pratt (2009), refers to moral judgments that emerge from unconscious processes and are typically accompanied by strong emotions. Although this type of implicit judgment has not been addressed in this article, the study of moral intuitions has been an active and fruitful field of research since the 1990s. In this regard, for instance, the *social intuitionist approach* (Haidt, 2001, 2007) suggests that many moral judgments do not arise from deliberate reasoning but from unconscious affect-laden processes (see also Dane & Pratt, 2009; Greene & Haidt, 2002; Haidt & Kesebir, 2008; Sonenshein, 2007).

Finally, Dane and Pratt (2009) suggest a third type of intuition, which they refer to as creative. According to them, creative intuition involves a synthesis of information in novel ways, integrating knowledge from various domains. Concerning the intuitive processes discussed in this article, the conceptualizations of Bowers et al. (1990, 1995) and Dijksterhuis (2004) are particularly relevant to this category. However, additional examples of creative intuition can be found in the literature (see e.g., Crossan et al., 1999; Eubanks et al., 2010; Raidl & Lubart, 2000/2001).

While the conceptualization of Dane and Pratt (2009) effectively differentiates various types of intuition within a broader framework, it is rather fuzzy with respect to the traditional notion of intuition within cognitive psychology. Accordingly, most of the intuitive processes discussed in this article fall under their category of problem-solving intuition. However, this categorization fails to distinguish between the relatively heterogeneous conceptions of intuition within this category.

2.9.2 Associative, Matching, Accumulative, and Constructive Intuition

Given the wide range of perspectives on intuition within cognitive psychology, Glöckner and Witteman (2010) propose that intuitive processes could be grouped into four categories. In this respect, they argue that intuition results from a number of different automatic processes that are based on distinct (but partially overlapping) mechanisms.

They suggest that processes in the first category of *associative intuition* rely on simple learning and retrieval processes, resulting in feelings of liking, or disliking or triggering previously successful behaviors. This, for instance, includes the implicit determination of frequencies and various forms of learned stimulus-response patterns (e.g., classical conditioning, operant conditioning, evaluative conditioning, social conditioning). In this regard, Slovic et al.'s (2002) affect heuristic (i.e., making a judgment based on the emotional response to a stimulus) falls within this category (cf. Glöckner & Witteman, 2010). The same applies to the intuitive preference for repeatedly presented stimuli (e.g., Zajonc, 1968, 1980) and may even apply to fluency experiences in general (e.g., Reber et al., 1998; Reber & Schwarz, 1999; Unkelbach, 2007).

Matching intuition, the second category proposed by Glöckner and Witteman (2010), encompasses more complex learning and retrieval processes. Specifically, it involves the comparison of the current situation or task with similar experiences from the past (i.e., with exemplars and prototypes stored in memory). This category includes, for instance, the intuitive processes underlying chess expertise (Simon and Chase, 1973), the rapid pattern-recognition processes suggested by Klein (1993), and probably also the analogy-based processes outlined by Hogarth (2010). In this respect, the suggested mechanism of matching intuition appears to be similar (though not as general) to Dane & Pratt's (2009) category of problem-solving intuition, which assumes a process of pattern recognition and matching.

While the first and second categories encompass rather general learning and retrieval processes, the third and fourth categories proposed by Glöckner and Witteman (2010) involve more complex information integration processes. Accordingly, processes within the third category, denoted as *accumulative intuition,* are assumed to integrate multiple sources of information, such as memory traces and/or currently perceived information, in parallel. Thus, this category encompasses processes that automatically accumulate evidence in favor of different options. During this process, each piece of information is assumed to be repeatedly examined and weighted according to its importance until a certain evidence threshold for one option is reached. Among the conceptualizations of intuition discussed in this article, the holistic processes described by Bowers et al. (1990, 1995) would most likely fall into this category. Similar process conceptions can also be found in evidence accumulation models of decision-making (cf. Glöckner & Witteman, 2010; see e.g., Busemeyer & Johnson, 2004; Busemeyer &Townsend, 1993; Ratcliff, 1978).

Finally, processes within the fourth category of *constructive intuition* involve not only a weighted accumulation of information, but also an automatic construction of mental models in which the relationships between individual pieces of information are preserved. Accordingly, processes within this category go beyond the comparison with exemplars from memory. They are assumed to create new consistent interpretations and combine existing information in novel ways (cf. Glöckner & Witteman, 2010). This conceptualization of intuition is particularly evident in the work of Glöckner and colleagues (e.g., Betsch & Glöckner, 2010; Glöckner & Betsch, 2008; Glöckner & Herbold, 2011; Jekel et al., 2012) but may also be applied to the processes described by Dijksterhuis (2004).

Taken together, Glöckner and Witteman (2010) provide a nuanced categorization of the potential processes underlying intuition, though it includes some degree of overlap. In this respect, the four categories are not entirely independent but could also reflect the same processes at a more abstract level (cf. Glöckner and Witteman, 2010). Nevertheless, their work provides a more differentiated framework for future research compared to dual-process models (Hogarth, 2010).

2.10 Conclusion

Unconscious mental functions have fascinated researchers since the early days of psychology. While the earliest investigations attempted to understand the inner workings of the mind through introspection, the limitations of this method soon shifted attention toward unconscious processes as essential components of human experience. As a result, since their initial conceptualization in the work of Sigmund Freud, unconscious mental functions have been studied by generations of researchers for their role in shaping perception, decision-making, and behavior. As psychology has evolved into the diverse field it is today, this has gradually reframed the notion of intuition from a somewhat mystical competence to a cognitive phenomenon grounded in the workings of unconscious mechanisms.

This shift has been heavenly influenced by the cognitive revolution, with its ideas still resonating in various contemporary accounts. Nevertheless, earlier psychological traditions have also left a lasting imprint on the field. As a result, particularly between the 1970s and 2000s, research on intuition has often been fragmented across intra-disciplinary boundaries, with some researchers building on depth psychology or gestaltism (e.g., Bowers et al., 1990; Epstein, 1990; Metcalfe, 1986; Myers, 1962), while others have drawn on classical cognitive frameworks such as Herbert Simon's concept of bounded rationality (e.g., Gigerenzer & Goldstein, 1996; Klein, 1993; Tversky & Kahneman, 1974). Against this background, it is hardly surprising that researchers have struggled to establish a comprehensive theory of intuition, as different schools of thought have approached the phenomenon based on rather unsimilar ontological assumptions and methodological preferences (Adinolfi & Loia, 2022).

Given the diverse perspectives that have been put forward following the emergence of cognitive research, it appears that there has been disagreement on one question in particular: Does intuition arise from sophisticated information processing outside of conscious awareness (e.g., Bowers et al., 1990; Klein, 1993; Reber, 1989)? Or is it the result of simpler (e.g., Gigerenzer, 1991; Gigerenzer & Todd, 1999), potentially even flawed heuristic mechanisms (e.g., Kahneman & Frederick, 2002; Tversky & Kahneman, 1974)? In essence, much of the controversy seems to revolve around the question that Loftus and Klinger aptly posed in their 1992 article: “Is the unconscious smart or dumb?” (see also Greenwald, 1992).

Nevertheless, it has become increasingly clear since the 1990s that “the unconscious” has a wide range of functions, some of which appear remarkably sophisticated and others more rudimentary. In this respect, a central focus of research in the 2000s has revolved around the question of when intuitive judgments can be trusted (e.g., Hogarth, 2001; Kahneman & Klein, 2009; Morewedge & Kahneman, 2010). Additionally, in more recent discussions, a growing number of researchers have expressed doubts about the viability of the dual-process perspective (e.g., Betsch & Glöckner, 2010; Dane & Pratt, 2009; Evans, 2008; Hogarth, 2010; Kruglanski & Gigerenzer, 2011).

Despite these challenges, recent years have brought increasing conceptual convergence. Scholars increasingly acknowledge the potential of bridging differing perspectives on intuition and how they could be meaningfully conceptualized into different intuitive phenomena (e.g., Dane & Pratt, 2009; Glöckner & Witteman, 2010; Gore & Sadler-Smith, 2011; Hogarth, 2010; Pretz & Totz, 2007; Sobkow et al., 2018). More generally, the growing skepticism toward rigid dichotomic models reflects a shift toward more nuanced perspectives, enabling a more comprehensive understanding of intuition and the fascinating adaptability of the human mind. Thus, considering how perspectives on intuition have advanced, this ongoing paradigm shift provides a promising foundation for future research. Because, as history has shown, the field has the potential to radically transform our understanding of the mind (cf. Glöckner & Witteman, 2010).

CHAPTER 3: THE ACCUMULATED CLUES TASK (ACT)

This chapter is based on the following article:

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Please note that some formatting changes were made to fit the layout of this dissertation. The content of the article remains unchanged. Data and materials are available at https://osf.io/et5kb.

Abstract

The Accumulated Clues Task (ACT; Bowers et al., 1990) is a semantic problem-solving paradigm that has primarily been used in research on intuitive processes and as an experimental model of insight. In this incremental task, participants are instructed to find a solution word that is implied by a list of clue words with increasing semantic proximity to the solution word. We present a German version of the ACT, consisting of 20 word lists with 15 clues each, and report norming studies testing its psychometric properties and their relations to psycholinguistic features of the stimulus material (total N = 300). The results are reported and discussed for future research employing this stimulus pool, which can be easily adapted to varying experimental set-ups and research questions.

Keywords: conceptual problem-solving, insight, intuition

3.1 Introduction

In a landmark paper that has stimulated a bulk of cognitive, social psychological, and personality research, Bowers and colleagues (1990) introduced three tasks that have since advanced our understanding of intuition and the underlying processes generating this enigmatic *feeling of knowing* (e.g., Koriat & Levy-Sadot, 2000; Metcalfe & Wiebe, 1987). Besides the Waterloo Gestalt Closure Task and the Remote Associated Test (originally adapted from Mednick, 1962), which today is a most prominent example for assessing intuitions of semantic coherence (e.g., Bolte & Goschke, 2005; Öllinger & von Müller, 2017), Bowers and colleagues presented a further language-based task, which they referred to as *the Accumulated Clues Task* (ACT). In this task, participants are presented with lists of clue words that refer to a solution word they are asked to guess.

Introduced as an experimental task assessing intuition (Bowers et al., 1990) and later framed as an experimental model of insight (Bowers et al., 1995), the ACT is an elegant model of implicit conceptual problem-solving (Reber et al., 2007). Intuition is knowing without being able to verbalize *how* one knows (e.g., Bolte & Goschke, 2005; Koriat & Levy-Sadot, 2000; Shirley & Langan-Fox, 1996; Vaughan, 1979) and insight is the abrupt realization of the solution to a cognitive problem after a period of conscious strategic study and then tacit unconscious elaboration (e.g., Bowden et al., 2005; Topolinski & Reber, 2010; Zander et al., 2016). Accordingly, participants in the ACT study the list clue for clue and incrementally narrow down the solution word by confirming hunches activated by earlier clues (Bowers et al., 1990).

Although the ACT is not a classic insight problem (see e.g., Webb et al., 2016, for a distinction between different types of insight tasks), it has indeed certain features that distinguish insight from non-insight problems (for a review of defining characteristics, see Batchelder & Alexander, 2012): (1) Each clue allows for several possible associations, however, only one of these associations leads to the solution word. (2) Most of the associations that emerge during the first clues are inadequate in that they do not lead to the correct solution word. (3) Once a productive association has emerged, it quickly leads to the solution, as this hunch can be confirmed based on the subsequent clues. (4) Solving a list involves the use of knowledge that is familiar to the solver; and (5) gaining insight into the correct solution word can be accompanied by an "Aha! experience", which is considered to be an important feature of insight problems (e.g., Bowden & Jung-Beeman, 2003b; Metcalfe & Wiebe, 1987; Reber et al., 2007; Topolinski & Reber, 2010; Zander et al., 2016).

In this regard, the ACT has been used as a fruitful tool to disentangle cognitive and meta-cognitive components in intuitive problem-solving and insight and to explore their relations to broader inter-individual differences (for reviews, see Dorfman et al., 1996; Hodgkinson et al., 2008; Runco, 2014; Shirley & Langan-Fox, 1996). Constructed by Bowers et al. (1990) to examine the convergence toward the solution in intuitive problem solving, Langan-Fox and Shirley (2003), for instance, explored the relations between the performance in the ACT with personality measures of intuition. Also, Reber et al. (2007) explored the meta-cognitive role of processing style and subjective feelings of closeness to the solution as well as relations to intelligence and personality. Further, it serves as a neat conceptual model exemplifying intuition, insight, and problem-solving (e.g., Öllinger & von Müller, 2017; Zander et al., 2016).

However, although the ACT has proven to be a versatile tool that can be adapted to a wide range of research questions, to date there is no published or standardized version of this instrument. Since the original version of the ACT created by Bowers et al. (1990) remained unpublished and, to our current knowledge, is no longer accessible, future researchers would need to create their own versions (such as e.g., Reber et al., 2007). This can be a time-consuming process and also raises questions about the comparability and informative value of the results.

For this reason, we report the development and test of a German version, which can easily be modified for use in various experimental settings, for instance, as a Deese-Roedinger-McDermott (DRM) paradigm (see discussion).

3.1.1 Aim and Objectives of the Present Work

Our goal was to create a modern standardized version of the ACT that would enable data collection in an online setting. However, given the fact that Bowers et al. (1990) first conducted the ACT more than 30 years ago, at a time when computer-based survey instruments were still a thing of the future, we aimed to adapt the original experimental procedure according to a more modern approach. Thus, on the one hand, we wanted to simplify the original task by refining or omitting procedural elements that were no longer needed in a computer-based environment. On the other hand, we wanted to create a more economical version of the task that Bowers et al. (1990) had described as “time-consuming and somewhat frustrating” (p. 86), as well as we were interested in providing participants with a more enjoyable and fluid experience. To this end, for example, we applied shorter presentation times for the stimuli and only strongly encouraged, but did not require, participants to suggest a possible solution word after each clue.

Although we were primarily interested in constructing a standardized stimulus pool for this interesting and versatile paradigm, we also wanted to examine this pool exploratively for its specific properties. In this respect, we were interested in how different measures of participants’ solution performance would be associated with each other and how some psycholinguistic parameters of our stimuli, such as the frequency of the clues in everyday language, would influence participants’ performance in this task.

3.2 Method

The original version of the ACT, consisting of 16 word lists with 15 clue words each, was constructed by Bowers and colleagues (1990) based on an adaption (Arthur, 1964) of the Kent-Rosanoff Word Association Test (Kent & Rosanoff, 1910). Specifically, they used responses that occurred infrequently (five times or less in 1000) in response to a particular stimulus word and randomly assigned them to a position between 1 and 12 in the sequence of an ACT's word list. For the last three clues, they used responses that occurred more frequently (more than five times in 1000) and randomly assigned them to be the thirteenth, fourteenth, or fifteenth clue of the ACT's list.

Since we did not have access to such a pool of data in German, where the associations between words can differ drastically from those in English, we conducted a pre-study to evaluate the individual association of each clue with the solution word, respectively. This also provided us with the opportunity to increase the clues' solution proximity more linearly throughout the final lists than was possible for Bowers et al. (1990; see discussion).

3.2.1 Pre-Study

The pool of word lists was derived in the following way. To ensure proper item power for the resulting task while keeping the development effort within reasonable limit, we arbitrarily settled for 20 lists to be construed. As a first step, 20 nouns were chosen from a dictionary of the German language that fulfilled the following criteria based on our subjective evaluation: They had to be frequently used in everyday language, be neutral in valence, be relatively short in length (3 to 9 letters), did not contain umlauts or the ligature ß, and could easily be re-combined with many other German nouns into compound words. For each of these 20 solution words, a first pre-selection of 25 to 30 associated words was derived from *Word Associations Network* (https://wordassociations.net). Criteria for this pre-selection of clues were that they had to be relatively neutral in valence, they had to be familiar to the vast majority of native German speaker, and they had to be associated with the respective solution word in a way, a large percentage of native German speakers would be able to retrace—either by being a synonym or a closely related term of the solution word, by being a descriptive or circumscribing term, by being frequently used together with the solution word, or by forming established compound words with it. Associated words (i.e., clues) were mostly nouns, but could also be verbs, adjectives, and adverbs.

Each word list was then evaluated a second time by two independent raters to ensure that the former criteria were met. Clues that did not fully met the criteria according to one of these raters were discarded. Subsequently, we conducted a pre-study to assess the semantic proximity of each of the remaining clues (17 to 20 per word list) to their solution word.

Due to the number of involved stimuli, the semantic proximity between the clues and the respective solutions per list was assessed in two independent batches employing each one half of the lists (completion time of the task approx. 16 min per batch). Based on the assumption that a sample of 100 individuals is sufficient to map the smallest differences of interest for this research question (see e.g., Brysbaert, 2019; Wilson VanVoorhis & Morgan, 2007), two samples of $N = 100$ each native German speakers (Sample 1: 58 male, 40 female, 2 gender-diverse; $M_{age} = 33$, $SD_{age} = 11$; Sample 2: 64 male, 35 female, 1 gender-diverse; $M_{age} = 28$, $SD_{age} = 8$) were recruited. Participants were recruited via the Online-Access-Panel *Prolific Academic* (https://www.prolific.co) and received £2.00 compensation. After an initial briefing (see the full briefing instruction at https://osf.io/et5kb), they were presented one at a time with word pairs, consisting of one solution word and one of the associated clues. Participants were asked to rate the proximity of these words (“How close are the words CLUE and SOLUTION?”) on a scale from 0 (*not close at all*) to 10 (*extremely close*). The mean proximity ratings of each clue and the corresponding solution word can be assessed in Appendix A. Based on the mean proximity ratings of this pre-study, clues with low discriminatory power (i.e., clues whose increment of proximity to the next clue was very low) were eliminated wherever possible and the word lists were reduced to 15 clues each. The subsequent testing of the resulting stimulus pool in the classical experimental setup will be reported in the following section.

3.2.2 Sample

Based on the recommendations of Brysbaert (2019) and Wilson VanVoorhis and Morgan (2007; see the *Pre-study* section), $N = 100$ native German speakers (60 male, 40 female; $M_{age} = 31$, $SD_{age} = 11$) were recruited via *Prolific Academic* and received £3.75 compensation.

3.2.3 Materials and Procedure

The experiment was conducted in an online setting employing the software application *Inquisit Web* (2016); we will provide the script for the experiment upon direct request. Participants were informed that the experiment investigated fundamental cognitive processes of language processing. They were instructed that they were going to be presented with lists of words and would, one at a time, see all words of these lists successively. In each word list, there would be exactly one solution word that would be implied by all of the clues with increasing semantic closeness to the solution word over the course of presenting the list. Their task would be to retrieve the solution word as soon as possible by typing in a suggestion for the solution word after each clue. It would not matter if they could not think of a potential solution word once, but they should try to always suggest a word if possible, just following their first impulse. The precise briefing instruction (original German version and English translation) can be assessed at https://osf.io/et5kb.

After the instruction, the 20 word lists (see Appendix A) were presented in random order and re-randomized anew for each participant. Before the presentation of each list in the experimental block, participants were informed that they were about to start with a new word list. Then, in ascending order of semantic proximity to the solution word, each clue of a list was presented on the screen for 2,000 ms.[1] To standardize the presentation procedure, all clues were presented in capital letters and their height was set to 8% of the screen. After the presentation of a given clue, a text box appeared and participants were prompted to enter a possible candidate for the solution word. In contrast to the procedure of Bowers et al. (1990), participants were able to skip the text box but were instructed to type in a potential solution word whenever possible. When the correct solution to a word list was given, a message appeared that the list had been solved successfully. Then, before the presentation of the next list, participants were once again informed that they were about to start with a new word list. They also received this message when the solution word was not generated after the 15th clue. At the end of the experimental block, participants completed some demographic questions and were asked if they had experienced any technical problems during the experiment. The average completion time for the experiment was 34 minutes.

3.3 Results

According to the procedure of Bowers et al. (1990), the solution performance for each list was operationalized by the number of clues needed by the participant to generate the solution word for a given list; this variable being called *clues required* hereafter. If participants were not able to generate the solution word by the 15th clue, the list was scored as non-solved. We only classified lists as solved if participants produced the preordained solution word.

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[1] This differs from the procedure of Bowers et al. (1990), in which the clues were shown for a minimum of 10,000 ms. each. However, after extensively testing, we concluded that two seconds were sufficient to process each clue (for demonstrations of the speed of semantic coherence discrimination and insight problem-solving, see Bolte & Goschke, 2005; Bowden & Jung-Beeman, 2003b).

Although it must be assumed that there are alternative solutions that make meaningful reference to most of the clues in a list, the existence of alternative solutions that relate to *all* 15 clues in this list appears highly implausible. This is because the clues not exclusively imply the solution word by being closely related terms, but also by alluding to common idiomatic expressions or by forming existing compound words with it. Therefore, based on the criterion that the solution had to be meaningfully associated with all clues in a list, only the solution word itself, its plural and verb forms, and misspellings of the solution word were accepted as correct.

The averaged psycholinguistic parameters for each list are presented in Table 3.1 in addition to the normative data from the present experiment. Across all word lists, an average of $M = 9.21$ ($SD = 1.26$) clues were required to generate the solution word for a given list and $M = 0.88$ ($SD = 0.03$) potential solution words were proposed per clue. There was a reasonable amount of variance in the average performance (i.e., clues required) across the sample (see Figure 3.1). In addition, there was sufficient variance in the lists' relative solution difficulty, ranging from an average clues required of $M = 4.97$ ($SD = 3.38$) for the list FABRIK (FACTORY) to a clues required of $M = 12.15$ ($SD = 2.35$) for the list PAAR (PAIR); see Table 3.1. Overall, $M = 66\%$ ($SD = 22\%$) of the participants solved a list with a maximum of 15 clues. We will refer to this variable as *solving probability* hereafter. The internal consistency (Cronbach's Alpha) of clues required and the word lists' solving probability was $\alpha = 0.83$ and $\alpha = 0.84$, respectively, which is superior to the $\alpha = 0.70$ reported by Bowers et al. (1990).

Table 3.1

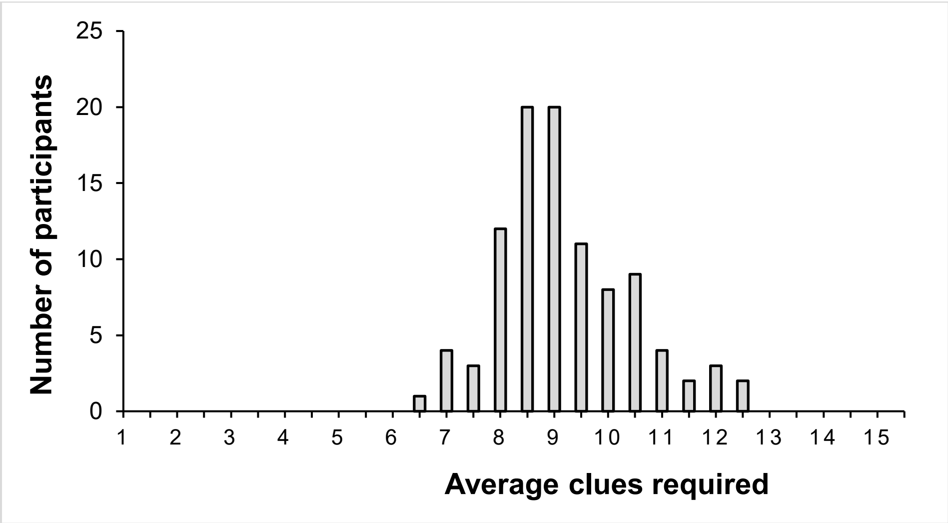
Mean clues required, solving probabilities, proposed solutions per clue, clue length, clue frequency in everyday language, and global solution proximity of the word lists

	Word list	Clues required *(SD)*	Solving probability	Proposed solutions	Clue length	Clue frequency	Solution proximity
1	Fabrik	4.97 *(3.38)*	58%	0.90	8.07	11.67	7.03
2	Bach	5.52 *(2.58)*	61%	0.93	6.00	12.73	6.43
3	Boot	6.77 *(2.73)*	84%	0.92	5.87	12.40	6.70
4	Marmor	6.92 *(2.96)*	65%	0.87	5.27	13.13	6.09
5	Zug	7.95 *(3.34)*	95%	0.90	6.87	11.87	6.55
6	Mund	8.40 *(3.39)*	83%	0.92	6.07	11.87	6.80
7	Lamm	8.47 *(2.96)*	55%	0.88	5.53	12.73	5.72
8	Silber	9.09 *(3.22)*	58%	0.90	6.07	13.00	6.54
9	Adler	9.32 *(2.57)*	77%	0.88	6.40	12.67	5.91
10	Treppe	9.34 *(2.35)*	91%	0.88	6.73	12.40	5.84
11	Glas	9.71 *(3.18)*	90%	0.86	6.80	12.67	6.38
12	Draht	9.78 *(2.81)*	49%	0.86	6.93	14.40	5.57
13	Nacht	10.11 *(3.25)*	83%	0.88	5.40	11.07	6.32
14	Schachtel	10.34 *(2.54)*	70%	0.88	7.47	12.80	5.88
15	Kuppel	10.36 *(3.77)*	42%	0.88	7.40	12.60	6.20
16	Mantel	10.44 *(3.00)*	61%	0.88	5.33	11.67	5.60
17	Salbe	10.75 *(4.06)*	73%	0.89	6.40	14.00	6.60
18	Punkt	11.32 *(4.26)*	31%	0.81	5.33	9.53	5.04
19	Knoten	11.79 *(3.32)*	48%	0.85	7.40	12.47	5.42
20	Paar	12.15 *(2.35)*	47%	0.87	6.20	12.07	5.42
	Total	**9.21 *(1.26)***	**66%**	**0.88**	**6.38**	**12.39**	**6.10**

Note. $N = 100$. Clues required (with standard deviations in parentheses) indicate the average number of required clues to generate the solution word for the given list. Solving probability indicates the percentage of participants who were able to generate the solution word with a maximum of 15 clues. Proposed solutions indicates the average number of proposed solution words per clue. Clue length indicates the average number of letters of the lists' clues. Clue frequency denotes the global frequency of the lists' clues in everyday language corpora (retrieved from https://corpora.uni-leipzig.de) with higher values denoting lower frequency. Solution proximity indicates the average semantic proximity of all clues of a list to the solution word of that list (data from pre-study).

Figure 3.1

Average clues required across the sample



3.3.1 Exploratory Analyses

The present rich performance data of 100 participants allowed further in-depth analyses of certain performance parameters and their relations to the psycholinguistic features of the word lists. We held no particular hypotheses regarding those relationships but examined them exploratively and report them here to stimulate future hypothesis development regarding driving cognitive mechanisms of the performance in this task. Table 3.2 presents the exploratory item-based correlation analysis among these list parameters.

Table 3.2

Bivariate correlations among list parameters

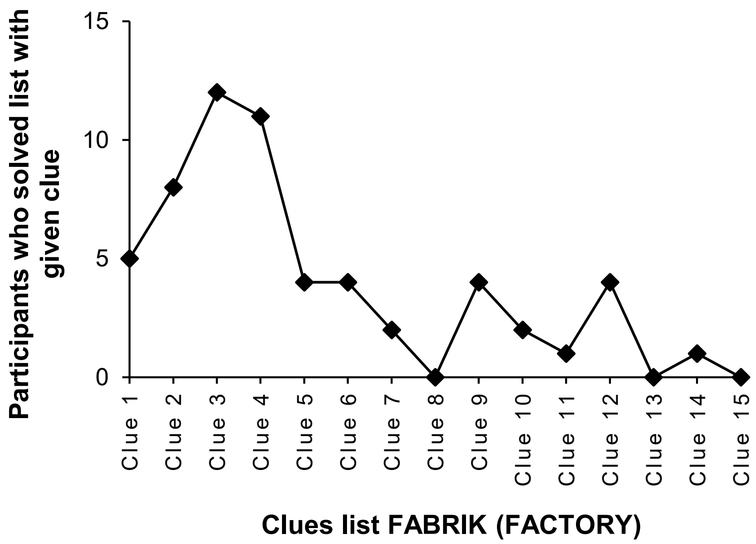
	1	2	3	4	5	6	7	8
1. Clues required [a]	—							
2. Solving probability	-0.30	—						
3. Proposed solutions	-0.66**	0.49*	—					
4. Clue length	-0.03	0.00	0.05	—				
5. Clue frequency	-0.09	0.12	0.28	0.28	—			
6. Solution frequency	-0.03	-0.11	0.05	0.22	0.66**	—		
7. First clue frequency	-0.28	-0.47*	-0.02	0.08	0.21	0.44*	—	
8. Solution proximity	-0.67**	0.56*	0.79**	0.21	0.19	0.02	0.02	—

Note. $N = 20$. [a] lower clues required indicate higher (faster) solution performance. * $p < 0.05$, ** $p < 0.01$.

First of all, intriguingly, within the present stimulus pool of 20 word lists, clues required and solving probability were not significantly correlated with each other, $r = -0.30$, $p = 0.197$. That is, the number of clues that participants required to solve the lists was unrelated to the proportion of participants who solved the lists at all. For instance, the list FABRIK (FACTORY) required the least clues for those participants who solved it, but its solving probability is comparatively low. Analyzing the frequencies of clues required for each list separately, we found that most lists featured one (or sometimes two) *critical spots* regarding the function between clues required and solving probability. These critical spots occur at certain sequences of clues (e.g., SCHLOT [CHIMNEY] – BACKSTEIN [BRICK] – KONZERN [CORPORATION], the first clues of the list FABRIK [FACTORY]) that seem to interact with each other and coalesce into a particularly strong intuitive hunch that increases the probability of solving the lists at these spots. At the same time, as illustrated in Figures 3.2 and 3.3 with the examples of the lists FABRIK (FACTORY) and SCHACHTEL (BOX), the solving probability tends to drastically decrease when the lists are not solved at these critical spots, which we deem as an explanation for the non-significant correlation between clues required and solving probability. We tentatively interpret these fascinating junctures as critical transition phases in the semantic representational space of a given list, which should be further explored in the future.

Figure 3.2

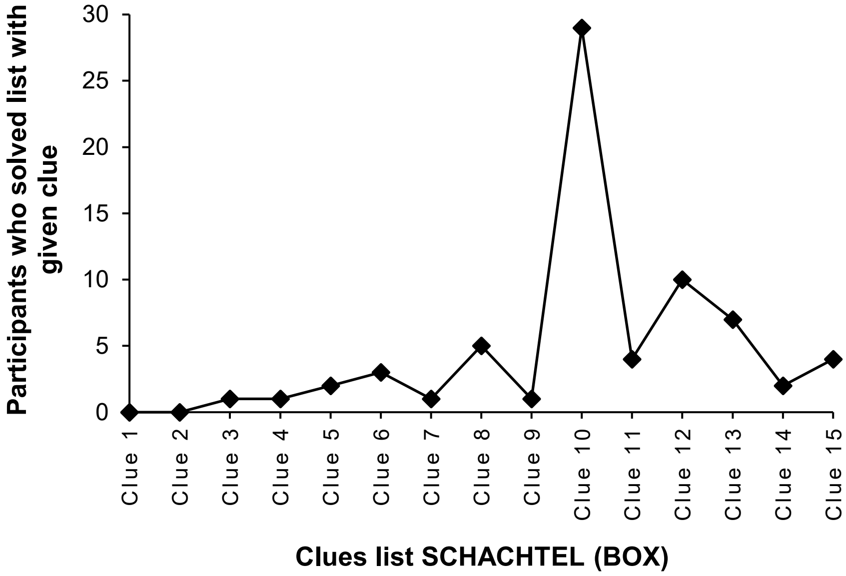
Frequencies of clues required for the list FABRIK (FACTORY)



Note. Number of participants who found the correct solution word with the respective clue over the course of the list FABRIK (FACTORY). $N_{solved} = 58$.

Figure 3.3

Frequencies of clues required for the list SCHACHTEL (BOX)



Note. Number of participants who found the correct solution word with the respective clue over the course of the list SCHACHTEL (BOX). $N_{solved} = 70$.

Further, the number of proposed solutions per clue correlated moderately to strongly with the clues required, $r = -0.66$, $p = 0.001$; as well as the solving probability, $r = 0.49$, $p = 0.028$. That is, the more potential solution candidates participants proposed, the faster they found the actual solution word and the higher their chance of solving the list was, although their solution propositions were not evaluated by feedback.

Clue length in letters did not relate substantially to any of the other measures (all *p*s > 0.213). We had only included clue length since it is a commonly controlled stimulus feature in research on accumulative semantic priming (e.g., Topolinski & Strack, 2009a, 2009b, 2009c) and a possible determinant of semantic fluency (e.g., Topolinski & Reber, 2010).

The frequencies of the clues and solutions in everyday language (retrieved from https://corpora.uni-leipzig.de; higher values mean lower frequency) yielded only the significant relationship that the more frequent the first clue of a given list was the more probably that list was solved across all participants (solving probability), $r = -0.47$, $p = 0.034$.

However, the frequency of the first clue did not substantially relate to clues required, $r = -0.28$, $p = 0.226$; and neither frequency of the whole list nor the frequency of the solution determined any solution outcome (all *p*s > 0.225). These null findings are at odds with the literature on word frequency and semantic priming, where high frequent words generate stronger priming (McNamara, 2005). This whole pattern is particularly striking given the fact that the only significant predictor was the frequency of the first clue, the clue farthest away from the solution in (list) space and (trial) time. This might be interpreted in the way that the first clue, when relatively familiar, increases the motivation or attention to engage with a given list in the first place (for similar effects in emotion processing accuracy, see Elfenbein & Ambady, 2003).

Regarding the semantic relationship between the list and its solution, the global proximity of the clues to their solution correlated moderately to strongly with clues required, $r = -0.67$, $p = 0.001$; the solving probability, $r = 0.56$, $p = 0.010$; and the number of proposed solution words, $r = 0.79$, $p < 0.001$, respectively. That is, the closer a list as a whole was to its solution semantically, the fewer clues were needed for solution, the more attempts were made to find the solution word, and the more participants solved a list eventually, which is in accordance with the literature on semantic relatedness and insight (e.g., Bowden & Jung-Beeman, 2003a; Bowden et al., 2005; Topolinski & Reber, 2010).

3.4 Discussion

A German version of the Accumulated Clues Task (Bowers et al., 1990) was constructed and its psycholinguistic properties were normed on $N = 300$ native German-speaking participants. We consider our version to be a modern replica of the instrument developed by Bowers et al. (1990), which unfortunately is no longer accessible. Since we are the first to publish a standardized stimulus pool for this task, our goal is to make it available to other researchers along with the normative information and psycholinguistic parameters of this instrument.

Our German version demonstrated appropriate variance in the solution difficulty of the individual lists and the solution performance of the participants. In addition, the present stimulus pool has a good internal consistency of $\alpha = 0.83$, which is higher compared to the version of Bowers and colleagues. However, this is most likely because our pool contains 20 lists instead of 16 (cf., Bowers et al., 1990).

Regarding the number of clues required to generate the correct solution word, our pool of lists appears to be slightly more difficult to solve, but fairly comparable to the original one by Bowers and colleagues. Accordingly, our participants arrived at the correct solution word with an average of $M = 11.39$ ($SD = 1.95$) clues,[2] compared to the $M = 10.12$ ($SD = 4.55$) clues reported by Bowers et al. (1990).

Apart from our main goal to construct a standardized stimulus pool for this interesting and versatile paradigm, we also wanted to examine this pool exploratively for its specific properties. The exploratory correlational analyses among the lists' properties yielded the following interesting results. First, the number of clues required to solve a given list did not significantly correlate with the general probability that this list was solved at all in the present sample. Rather, most lists happened to feature critical sequences of clues (at varying junctures across the lists) that phasically boosted solution likelihood. When participants did not retrieve the correction solution at these sweet spots, overall probability of finding the solution decreased drastically. We can only speculate about the nature of these sweet spots. Possibly, at

[2] The average clues required reported here was calculated according to the slightly different scoring procedure of Bowers et al. (1990), who assigned a clues required of 16 to non-solved lists.

these junctures in the list the clues were effective to critically re-organize the multi-dimensional semantic space (cf. Rodd, 2020) of the cognitive representation of the list prompting its common semantic denominator. When participants did not retrieve the solution at this juncture, they might have deviated into testing remote semantic hypotheses that were not supported by the further upcoming clues, or lost motivation in engaging with the list at all. Future research should further explore this most interesting finding.

Second, neither the global word frequency of the list nor that of the solution determined solution performance, as one would expect from the literature on semantic priming (e.g., McNamara, 2005; Plaut & Booth, 2000), but selectively the word frequency of the first clue determined the eventual solving of a given list. Yet again, this frequency of the first clue did not substantially correlate with clues required to solve the list. This suggests a rather motivational than automatic spreading mechanism: The familiarity of the very first clue triggered motivation to engage with the list and find its solution (see for familiarity and stimulus encoding depth, Elfenbein & Ambady, 2003). If an automatic spreading route would have taken course, first-clue frequency would have (negatively) correlated with clues required, since the high-frequent first clues would have activated solution-related information more efficiently than low-frequent first clues. Crucially, future studies might actively manipulate the familiarity or fluency of the first clue (e.g., by pre-exposure) to test this experimentally.

Third, the semantic solution proximity of the list as a whole determined solution performance. This is perfectly in line with the literature on semantic priming showing that close semantic relations generate higher priming effects than distant relations (e.g., Kiefer et al., 1998; McNamara & Healy, 1988; Spitzer et al., 1993; Topolinski & Deutsch, 2013).

As stated in the previous sections, we opted for a slight adaption of the original experimental procedure to create a more modern, economic, and less frustrating task. Let us briefly consider how each of these adaptions may have affected the general quality of our task. Our experimental procedure differs from that of Bowers and colleagues (1990) mainly in four aspects:

First, in our version of the ACT, the solution proximity of the clues increases more linearly to the solution word, whereas in the original version, the first 12 clues possess equally low solution proximity, while the last three clues are more closely associated with the solution word. It is conceivable that our linear progression towards the solution leads to a slightly slower insight into the solution word, however, given the similar average clues required reported by Bowers et al. (1990), this seems rather negligible.

Second, in contrast to the original procedure, we strongly encouraged, but did not require, participants to suggest a possible solution word after each clue. Considering the nevertheless satisfactory rate of $M = 0.88$ proposed solutions per clue, this should not represent a limitation of our procedure either.

Third, compared to the original procedure in which the first clue was presented for 15 seconds and the presentation intervals for subsequent clues became progressively shorter, down to a minimum of 10 seconds (cf., Bowers et al., 1990), we applied drastically shorter presentation intervals of 2 seconds per clue (for demonstrations of the speed of semantic coherence discrimination and insight problem-solving, see e.g., Bolte & Goschke, 2005; Bowden & Jung-Beeman, 2003b). The advantage of this adaptation is corroborated by our results, which show that participants were nevertheless able to solve the lists with a similar number of clues as in the original procedure.

Fourth, in contrast to our present procedure, Bowers et al. (1990) additionally asked participants to indicate promising solutions but to continue the lists until they were convinced that their solution was correct. The fact that we did not implement this additional step is mainly due to the different objectives of our research. Whereas Bowers et al. (1990) aimed to study the process of gaining insight into the solution, we were primarily interested in constructing a standardized stimulus pool that could be adapted to a wide range of research questions. In this regard, our task can easily be modified to explore procedural aspects of intuitive problem-solving and insight, for example, by instructing participants to indicate potentially promising solutions and to decide for themselves when to declare the lists satisfactorily solved.

3.4.1 Implementation in Different Areas of Research

The present stimulus pool is not only a versatile tool in the field of intuitive problem-solving and insight but could also be modified for other areas of cognitive research. For instance, the stimulus architecture (not the task) of the ACT resembles the well-known Deese-Roedinger-McDermott (DRM) paradigm. In this paradigm assessing the emergence of false memories, participants are shown a list of words that are all associated with a common denominator that is itself not presented (Roediger & McDermott, 1995). As a result, in later memory probing participants erroneously report having seen the implied but not presented common denominator (e.g., Storbeck & Clore, 2005; Van Damme, 2013; for reviews, see Roedinger et al., 1998; Schacter, 1999). Although previous researchers have produced a number of German DRM lists (e.g., Stegt, 2006), to our current knowledge these are not publicly available and the pool of lists is limited. To avoid the time-consuming process of creating new German DRM lists when a larger number of stimuli is required, the present stimulus pool also offers the possibility of modification into a DRM set-up. The only difference between the ACT and the DRM (except participants' task) is that the clues are presented in increasing semantic relatedness to the solution in the ACT, while there is no such incremental semantic determination in the DRM (which is why DRM lists cannot be converted to ACT lists, but only the other way around). This can easily be modified by presenting the present clues in random order and probing later memory.

3.4.2 Conclusion

In conclusion, the present report provides a standardized German version of the ACT for use in future research that can be easily adapted to varying experimental set-ups and research questions. For instance, future research can explore the impact of psychological variables such as cognitive mind-sets, creativity inductions, mood, and motivation selectively on easy and hard ACT items. Also, already the present explorative analyses brought about novel research avenues, such as the role of familiarity of the initial clue or the appearance of semantic sweet spots along a given list that foster or inhibit eventual problem solving—both phenomena to be further explored.

CHAPTER 4: INTUITION – A PSYCHOMETRIC EXPLORATION

This chapter is based on the following manuscript:

Löffler, C. S., Glöckner, A., & Topolinski, S. (2025). Intuition: A psychometric exploration. *Manuscript in preparation*.

Please note that some formatting changes were made to fit the layout of this dissertation. The content of the manuscript remains unchanged. All data, analysis scripts, and materials are available at https://osf.io/yw8bc.

Abstract

Intuition has been conceptualized based on a broad spectrum of psychological phenomena. Equally diverse are the measurement methods that have been applied, however, the interrelationships among these instruments remain largely unclear. In a preregistered experiment ($N = 219$), we examined the associations between two questionnaires (Myers-Briggs Type Indicator, Rational-Experiential Inventory) and six performance measures (Cognitive Reflection Test, Anchoring Paradigm, Remote Associates Test, Accumulated Clues Task, Gestalt Closure Task, Artificial Grammar Learning Paradigm) corresponding to different theoretical conceptualizations of intuition, as well as each measure's relationship to intelligence, openness, neuroticism, and conscientiousness. No association was found between the intuitive components of the questionnaires, nor did they positively align with any performance measure. A distinct factor emerged from performance measures of coherence and insight that was predicted by crystallized intelligence, fluid intelligence, and openness. In contrast, other performance measures were largely independent of the remaining instruments, as well as of personality traits and cognitive ability. The findings are discussed in light of previous research and dual-process theories of cognition.

Keywords: intuition, heuristics, coherence, insight, personality, intelligence

4.1 Introduction

In recent decades, the study of intuition has gained significant attention in psychology and beyond. Nevertheless, despite its prominence in contemporary research, the phenomenon of intuition remains a subject of debate. In this respect, perspectives on what intuition is, how it works, and to what extent it can lead to good decisions have varied widely (Glöckner & Witteman, 2010; Hogarth, 2001; Plessner et al., 2008).

Reflecting these diverse views, researchers have employed a broad range of methods to study intuitive functions, ranging from self-report questionnaires (e.g., Myers, 1962; Pacini & Epstein, 1999) to various performance measures (e.g., Bowers et al., 1990; Frederick, 2005; Mednick, 1962; Reber, 1967). However, given that these measures are based on different theoretical assumptions about intuition, there is little evidence to determine whether they are meaningfully associated or capture fundamentally different cognitive processes.

Further, while some dual-process models suggest that unconscious processes are largely independent of individual traits (e.g., Reber, 1993; Stanovich, 1999; see Evans, 2008, for a review), there is evidence that individual differences may indeed influence certain intuitive functions (e.g., Baumann & Kuhl, 2002; Kaufman, 2011; Langan-Fox & Shirley, 2003; Sobkow et al., 2018). This raises important questions about whether intuition can be understood as a multifaceted construct or if it merely serves as a broad label for a diverse set of cognitive phenomena (cf. Glöckner & Witteman, 2010).

To address these questions, the current experiment will assess the convergent validity between two questionnaires and six performance measures, and explore their relationships with personality traits and cognitive abilities. In the following sections, we will first discuss key definitions of intuition from different research traditions, and then outline the measurement approaches to be employed.

4.1.1 Defining Intuition

In a nutshell, two prominent conceptualizations of intuition have emerged in the literature, each of which has developed unique measurement approaches (see Pretz & Totz, 2007; for the distinction into heuristic and holistic approaches). While there is broad agreement on the subjective experience of intuition as a sense of knowing (e.g., Bowers et al., 1990; Deutsch & Strack, 2008; Epstein et al., 1996; Gigerenzer, 2007; Kahneman & Klein, 2009; Metcalfe & Wiebe, 1987; Vaughan, 1979), there are, however, competing theories regarding the mechanisms underlying intuitive phenomena.

4.1.1.1 Intuition as Heuristic Process

The first of these dominant approaches equates intuition with heuristic processes—shortcut strategies to analytical processes in which multiple steps have been omitted or modified (e.g., Gigerenzer, 2007; Hill, 1987; Tversky & Kahneman, 1974; Westcott, 1968). According to this notion, individuals tend to base their decisions on a reduced amount of the available information, resulting in a fast but sometimes incorrect solution (Betsch & Glöckner, 2010; Kahneman & Frederick, 2002; Morewedge & Kahneman, 2010).

Examples of these heuristics strategies include the availability heuristic, in which the first example that comes to mind is used as a cue for the plausibility or frequency of events; or the anchoring heuristic, in which a numerical assessment is adjusted based upon a previously presented number (see e.g., Tversky & Kahneman, 1974). While these heuristics are typically considered automatic, some, like the recognition heuristic, have been characterized as deliberate mechanisms (Gigerenzer & Goldstein, 1996).

4.1.1.2 Intuition as Holistic Process

While the heuristic approach views intuitive processing as a strategy to reduce cognitive effort, proponents of the holistic approach argue that this perspective is overly reductionistic (e.g., Betsch & Glöckner, 2010; Bowers et al., 1995; Hill, 1987). According to this alternative view, intuitive judgments are the result of integrating various sources of information in a holistic, parallel manner (e.g., Betsch & Glöckner, 2010; Deutsch & Strack, 2008; Epstein, 1990, 2008). Accordingly, holistic intuitive judgments differ from analytic judgments in that they synthesize complex information in a holistic manner rather than through sequential, logical analysis. Further, they occur independently of intention (e.g., Hogarth, 2001; Topolinski & Strack, 2008) and often unfold with little or no conscious awareness of the process itself (e.g., Betsch, 2008; Betsch & Glöckner, 2010; Hammond, 1996; Pretz & Totz, 2007).

4.1.2 Measuring Intuition

While the definition of intuition varies widely across research traditions, the range of measurement approaches used to study it has been even more diverse. Beginning with classical questionnaires, the field has gradually evolved to include more objective approaches designed to capture intuition as either a heuristic or holistic performance.

4.1.2.1 Questionnaires

One of the first examples of an inter-individual approach is the *Sensing/Intuition Scale* (SN) from the Myers-Briggs Type Indicator (MBTI; Myers, 1962). Based on the controversial Jungian personality types, the scale assesses a person's individual preference for certain types of perceptions and judgments (Myers & McCaulley, 1989). In this regard, it is suggested that the two poles of the scale each reflect the bipolar dimensions of the hypothesized spectrum between sensing and intuitive personality types. Whereas low scores on the scale reflect a preference to acquire information through concrete and directly observable facts (sensing), higher scores reflect a tendency to imagine abstract relationships and to intuitively *feel* patterns rather than observing them concretely (intuition; see e.g., Pretz & Totz, 2007; Myers & McCaulley, 1989).

Another well-established questionnaire is the Rational-Experiential Inventory (REI; Epstein et al., 1996; Pacini & Epstein, 1999), which is grounded on the dual-process model of cognitive-experiential self-theory (CEST; Epstein, 1990). In accordance with other dual-process models of human cognition, CEST proposes that information is processed by two parallel, interactive systems. The *rational system* operates intentionally, analytically, and is consciously assessable, whereas the *experiential system* is automatic, unconscious, and affect-driven. In the original version of the REI (Epstein et al., 1996), the instrument consists of two subscales representing these independent processing modes. While the *Need for Cognition Scale* (NfC; corresponding to the rational system; originally adapted from Cacioppo and Petty, 1982) assesses the tendency to engage in rational information processing, that is, to make decisions based on analytic and deliberate reasoning; the *Faith in Intuition Scale* (FI; corresponding to the experiential system) captures a person's tendency to base their decisions on immediate responses and intuitive gut feelings (cf. Epstein et al., 1996; Pacini & Epstein, 1999).

4.1.2.2 Heuristic Performance Tasks

In addition to these classical self-assessment scales, a number of tasks have been employed to capture intuitive processes in a performance-based approach. In this respect, performance measures derived from the heuristic account usually assess an individual's decision accuracy in the presence of biasing information.

One of the most prominent instruments in the heuristics-and-biases literature is the Cognitive Reflection Test (CRT; Frederick, 2005). It consists of questions that seem straightforward at first glance but require individuals to suppress an intuitive yet incorrect response in favor of a more analytical solution. As such, the CRT has often been characterized as an indicator of analytic vs. heuristic reasoning (Erceg & Bubić, 2017; Toplak et al., 2011, 2014).

Another paradigm that has frequently been associated with heuristics-and-biases in decision-making is based on the strikingly robust phenomenon of judgmental anchoring (Englich & Soder, 2009). The fundamental premise of classical Anchoring Tasks states that individuals are susceptible to previously experienced information (McElroy & Dowd, 2007) and will assimilate their numeric estimates towards this initially considered standard (Englich & Soder, 2009; Mussweiler et al., 2000). Accordingly, Anchoring Paradigms typically consist of two questions, the first of which is comparative and the second absolute. While in the comparative question, the anchor is set by letting participants decide whether it is higher, lower, or identical to a quantity of interest, in the subsequent absolute question, participants are instructed to precisely estimate this quantity (Englich & Soder, 2009).

4.1.2.3 Holistic Performance Tasks

In parallel with the emergence of heuristic performance tasks, other authors have developed instruments that attempt to capture intuition as a holistic process. Unlike measures of heuristic processing, many of these are concerned with the measurement of coherence perception. In the following, we will distinguish between semantic and perceptual tasks, since it cannot be assumed that the processes involved in these tasks necessarily rely on the same cognitive mechanisms (cf. Bowers et al., 1995; Evans, 2008; for a more in-depth discussion, see the *Hypotheses* section).

Holistic Semantic Processing. A most prominent example for assessing semantic insight problem-solving and intuitions of semantic coherence is the Remote Associates Test (RAT; Mednick, 1962). In this test, participants are presented with apparently unrelated word triads that either share a common remote associate (indicating coherence) or do not (indicating incoherence). While it is assumed that holistic intuitive judgments are formed by sensing the solution without explicit representation of it (i.e., knowing without knowing how; cf. Epstein, 2008), insight problem-solving is characterized by an abrupt solution retrieval after a period of tacit unconscious elaboration (e.g., Bowden et al., 2005; Topolinski & Reber, 2010; Zander et al., 2016). Although the RAT can be used to study this process of explicit insight into the solution, it also provides evidence that individuals can quite accurately discriminate between coherent and incoherent triads without retrieving the associated solution (e.g., Baumann & Kuhl, 2002; Bolte et al., 2003; Topolinski & Strack, 2009a, 2009b, 2009c).

A further semantic measure of insight problem-solving is the Accumulated Clues Task (ACT; Bowers et al., 1990). In this task, participants are instructed to sort out a specific solution word with limited clues. To this end, they are presented one at a time with clue words, each of which exhibits a closer association with the solution than the previous one. Accordingly, the solution performance in the ACT is operationalized by the amount of information participants require to generate a correct hypothesis (Bowers et al., 1990; Löffler & Topolinski, 2023). This solution retrieval can be accompanied by a sudden "Aha! experience", which generally characterizes the experience of insight problem-solving (e.g., Bowden & Jung-Beeman, 2003a; Metcalfe & Wiebe, 1987; Topolinski & Reber, 2010; Zander et al., 2016).

Holistic Perceptual Processing. A further task, relying on visual coherence perception, is the Gestalt Closure Task (GCT; Bowers et al., 1990). In this task, participants are confronted with highly degraded drawings showing either everyday objects (coherent) or random visual information (incoherent). Although the objects in question are rarely identified, people are able to discriminatively respond to images of objects, suggesting their intuitive sensitivity to visual coherence (Bowers et al., 1990; see also Topolinski & Strack, 2009b; Volz & von Cramon, 2006; Wippich, 1994).

Another task, assessing intuitions of grammaticality, goes back to Reber's (1967) pioneering work on implicit learning. In this artificial grammar learning paradigm (AGL), participants are presented with letter strings that are either constructed based on an implicit artificial grammar or randomly generated. After being exposed to a series of grammatical strings during a study phase, participants can discriminate above chance, whether a letter string is based on artificial grammar, without being aware of the underlying grammatical principles (Perruchet & Pacteau, 1990; Reber, 1967; see Pothos, 2007, for a review).

4.1.3 On the Relationships Between Different Measurement Approaches

Considering the heterogeneous patchwork of measurement approaches surrounding the term intuition, research addressing the convergent validity among these instruments is scarce. Accordingly, it remains largely unexplored to what extent different measures of heuristic and holistic performances are associated among themselves, associated with each other, and whether there is a relationship between questionnaires and performance-based approaches.

A first attempt to provide a framework for this question (Hill, 1987) dates back more than 30 years, concluding that the assessed questionnaires were correlated with each other, but not with a heuristic performance task. A further study (Pretz & Totz, 2007) found that subscales of the REI and MTBI partially overlap, suggesting a distinction between affective, heuristic, and holistic aspects of intuition (see also Dennin et al., 2022). This distinction, however, has been limited to self-report questionnaires, as no performance-based approaches have been examined.

Most recently, Sobkow and colleagues (2014, 2018) proposed a distinction between measures of coherence and insight, implicit learning, and subjective intuitive abilities, demonstrating that these dimensions exhibit different patterns of relationships with personality traits and cognitive abilities. According to this distinction, measures of coherence and insight require the ability to combine information from long-term memory in a holistic, parallel manner. Implicit learning is characterized by the capacity to spontaneously detect complex patterns of information, while subjective intuitive abilities (assessed through questionnaires) involve metacognitive feelings about one’s own intuitive ability and a preference for its use (cf. Sobkow et al., 2018). Although we were unaware of this work when we initiated the present project, our experiment will further examine the associations between different measures and their relationship with individual traits.

4.1.4 The Role of Individual Traits

4.1.4.1 Openness to Experience

Among the Big Five personality traits (Costa & McCrae, 1992), the factor most commonly associated with intuitive functions is openness to experience (see also Sobkow et al., 2018, for a review). Indicating a general preference for variety, a tendency toward intellectual curiosity, and creativity (McCrae & Costa, 1987, 1989), openness has been consistently found to have positive associations with both the SN scale from the MBTI (e.g., Furnham et al., 2003; Langan-Fox & Shirley, 2003; McCrae & Costa, 1989; Sobkow et al., 2018; Topolinski & Hertel, 2007) and the FI scale from the REI (e.g., Alós-Ferrer et al., 2016; Keller et al., 2000; Pacini & Epstein, 1999; Reber et al., 2007; Witteman et al., 2009).

Nevertheless, the relationship between openness and intuitive functions appears to be more pronounced for self-report scales (cf. Sobkow et al., 2018), whereas there is mixed evidence for performance-based approaches. In this regard, openness has been linked to superior cognitive reflection in the CRT (e.g., Teovanović et al., 2015), but has also been associated with susceptibility for judgmental anchoring (e.g., McElroy & Dowd, 2007). Moreover, some studies found that individuals higher in certain aspects of openness correctly solved more word triads in the RAT (Aitken Harris, 2004; Sobkow et al., 2018), while other studies did not support this relationship (see Lee et al., 2014, for the RAT; Langan-Fox & Shirley, 2003, for the ACT).

4.1.4.2 Neuroticism

Neuroticism, another dimension of the Big Five, has also been associated with intuitive functions. In this respect, neuroticism—characterized by a susceptibility to negative feelings and emotional instability (McCrae & Costa, 1989)—has been negatively associated with the intuition dimension of the MBTI (e.g., Furnham et al., 2003) and the REI's FI scale (e.g., Witteman et al., 2009).

Although there is limited evidence on the association between neuroticism and intuitive performance tasks, it is conceivable that neuroticism may be a factor that interferes with intuitive processes due to its affective nature (for a demonstration of how affective states can influence intuitive judgments in the RAT, GCT, and AGL; see Baumann & Kuhl, 2002; Bolte et al., 2003; Remmers et al., 2015; Remmers et al., 2017; Topolinski & Strack, 2009a, 2009b, 2009c). Correspondingly, individuals high in neuroticism have been found to be more susceptible to the recognition heuristic (Hilbig, 2008), the availability heuristic, and the representativeness heuristic (Belhekar, 2017).

4.1.4.3 Conscientiousness

As a well-established predictor of task performance (e.g., Debusscher et al., 2017; Gellatly, 1996; Meyer et al., 2009), we will finally examine conscientiousness for its potential influence on intuitive processes. Conscientiousness includes the disposition for persistence, self-discipline, and achievement orientation (McCrae & Costa, 1989). With respect to the questionnaires, conscientiousness has been relatively consistently associated with both of the REI's scales (e.g., Alós-Ferrer et al., 2016; Epstein et al., 1996; Pacini & Epstein, 1999; Witteman et al., 2009), but interestingly not with the MBTI's SN scale (e.g., Furnham, 2022).

In addition, conscientiousness has been linked to various performance-relevant behaviors (e.g., Debusscher et al., 2017; Meyer et al., 2009) and has also been associated with heuristic/holistic tasks. Accordingly, Eroglu and Croxton (2010) found that highly conscientious individuals were more susceptible to the anchoring bias (see also Furnham et al., 2012; McElroy & Dowd, 2007). Contrarily, the findings of Reber et al. (2007) suggest that conscientiousness is associated with solution speed in the ACT.

4.1.4.4 Intelligence

Although some dual-processing accounts have proposed that unconscious and automatic processes are relatively independent of intelligence (e.g., Evans, 2008; Reber, 1993; Stanovich, 1999), other authors have argued that implicit processes make an important contribution to explicit cognitive functions and, in turn, that cognitive abilities may influence intuitive processes (e.g., Kaufman, 2011; Sobkow et al., 2018). Correspondingly, previous research has revealed various associations between cognitive ability and established measures of intuitive functions.

With respect to the questionnaires, intelligence has been found to positively correlate with the MBTI's SN scale (e.g., Kaufman et al., 1996; Moutafi et al., 2003), whereas Alaybek and colleagues' (2021) meta-analysis found a non-significant (and also negative) relationship between intelligence and the REI's FI scale.

Among the performance measures, especially cognitive reflection in the CRT has been demonstrated to correlate substantially with general intelligence (e.g., Carroll, 1993; Deary, 2012; Otero et al., 2022). In contrast, although other heuristic tasks have previously been linked to cognitive ability (e.g., Belhekar, 2017; Michalkiewicz et al., 2018), most studies conclude that the anchoring bias is relatively independent of intelligence (e.g., Furnham et al., 2012; Stanovich & West, 2008).

According to Sobkow et al. (2018), the relationship between cognitive ability and intuitive processing appears to be more consistent for measures involving coherence judgments and insight problem-solving. Correspondingly, a substantial number of studies have revealed associations between performance in the RAT and various intelligence measures (e.g., Barr et al., 2015; Bowers et al., 1995; Chermahini et al., 2012; Lee et al., 2014; Sobkow et al., 2018; Taft & Rossiter, 1966). Further, there is evidence that the ACT is associated with intelligence (Bowers et al., 1995; Reber et al., 2007), although these findings have so far been limited to measures of crystallized intelligence.

While the positive relationship between cognitive ability and these semantic measures has been comparatively well established, it remains unclear whether the GCT, as a measure of visual coherence detection, is also associated with intelligence. Likewise, there is mixed evidence on the relationship between artificial grammar learning (AGL) and cognitive ability, suggesting that there is at most a weak relationship (e.g., Danner et al., 2011; Gebauer & Mackintosh, 2007; Reber et al., 1991; Sobkow et al., 2018). Thus, in summary, the evidence for a relationship between cognitive ability and intuitive processing is mixed, suggesting that the present instruments capture distinct cognitive processes and do not correspond to a unitary construct of intuition.

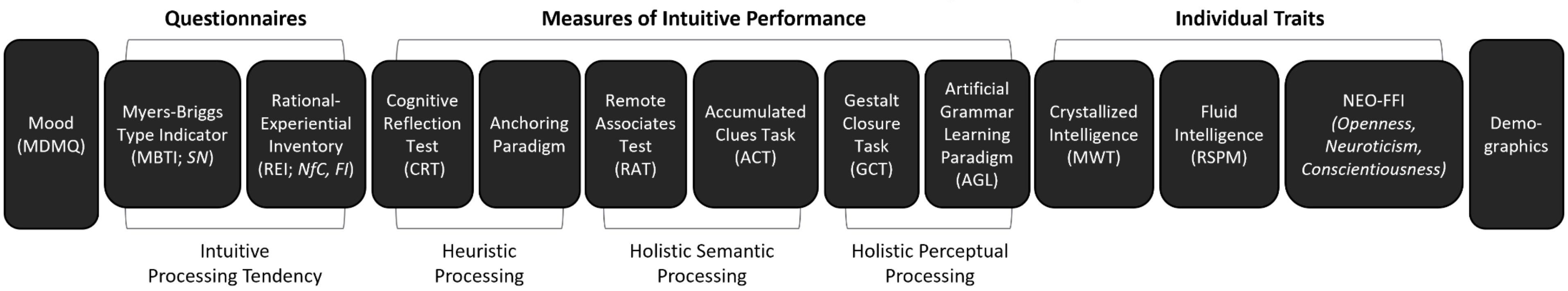
4.1.5 Aim and Objectives

Given the heterogeneous patchwork of measurement approaches surrounding the term intuition, neither the relationships among the instruments themselves nor their respective associations with personality traits and cognitive ability are consistent or well understood. Nevertheless, despite the challenges posed by this inconsistent empirical foundation, it seems critical to systematically examine the associations between different instruments and their relationships with individual traits. In this respect, there is sufficient evidence to suggest that while there is no unitary construct of intuition, there is common variance across some of these instruments.

To this end, the present experiment (preregistered, https://aspredicted.org/THA_TPD) will investigate the associations between the two questionnaires and six performance measures corresponding to different conceptualizations of intuitive processing. Additionally, we will assess each measure's relationship to crystallized and fluid intelligence (see Cattell, 1963; for the distinction between crystallized and fluid aspects of intelligence), openness, neuroticism, and conscientiousness (see Figure 4.1 for an overview of all measures assessed in the experimental battery).

Figure 4.1

Full experimental procedure



Note. Between the initial mood assessment and the final demographic assessment, all measures were presented in random order. Designations in italics refer to subscales within an instrument.

4.1.6 Hypotheses

Although we consider our experiment primarily as an exploratory investigation, we will test the following hypotheses regarding the associations between different instruments. While we assume that most of these instruments are based on different cognitive mechanisms, there are indications that there is shared variance among several instruments.[3]

4.1.6.1 Expected Correlations

Based on previous findings (e.g., Edwards et al., 2002; Pretz & Totz, 2007), we hypothesize that measures of self-reported intuitive processing tendency (MBTI, REI) will be positively correlated. Furthermore, there is evidence to suggest a common or very similar mechanism underlying problem-solving performance in measures of semantic coherence and insight. both the RAT and ACT. Accordingly, the RAT and ACT have been found to be positively associated with each other (Bowers et al., 1995) as well as with crystallized intelligence (Bowers et al., 1995; Reber et al., 2007). Thus, we hypothesize that performance in the RAT and ACT will be positively correlated.

Regarding a potential relationship between measures that originate from a holistic conceptualization of intuition but do not involve the processing of semantic stimuli, there is little previous evidence on which to draw. On the one hand, it is conceivable that performance

[3] It should be noted that at the time we planned our experiment, we were unaware of Sobkow et al.'s (2018) distinction between measures of coherence and insight, implicit learning, and subjective intuitive abilities. While their findings are promising, they certainly challenge some of our preregistered hypotheses. Thus, although we did not originally conceptualize this project around the distinction of Sobkow and colleagues (2018), we will discuss it in light of our hypotheses. In addition, we will test whether their findings can be replicated using our different set of instruments (see the *Results* section).

in these measures relies on different cognitive mechanisms. For instance, judgments of visual coherence in the GCT may be based on a mechanism of coherence and insight (cf. Sobkow et al., 2018) or even on the activation of semantic networks (Bolte & Goschke, 2008), while artificial grammar intuition in the AGL may be rooted in implicit learning (Sobkow et al., 2018). On the other hand, it is also plausible that the cognitive processes involved in the GCT and AGL share a common mechanism of similarity detection (see e.g., Pothos, 2007; see also Glöckner & Witteman's, 2010, account of *matching intuition*), whereby incoming information is compared to category exemplars stored in memory. Challenging Sobkow et al.'s (2018) distinction, we will tentatively hypothesize that performance in the GCT and AGL will be positively correlated (Hypothesis 1c).

4.1.6.2 Null Hypotheses

In addition to these directed hypotheses, we will test against the following null hypotheses regarding the relationships of measures from different theoretical accounts and expect them to hold for potentially small effects. We will test these hypotheses under the basic assumption that the term intuition is a common label for a set of different cognitive phenomena (cf. Glöckner & Witteman, 2010).

Regarding the question of whether individual processing styles (assessed through the MBTI and REI) are associated with intuitive performances, previous research has yielded conflicting results (for the MBTI's SN scale, see Langan-Fox & Shirley, 2003; Sobkow et al., 2018; for the REI's FI scale, see Pennycook et al., 2016; Reber et al., 2007). Given these inconsistent findings, we propose that the questionnaires (SN scale, MBTI; FI scale, REI) will not be positively correlated with the performance-based approaches (CRT, Anchoring Paradigm, RAT, ACT, GCT, AGL).[4]

Additionally, considering the lack of a common framework, there is no evidence to suggest any relationship between heuristic and holistic instruments. Thus, we hypothesize that performance in measures of heuristic processing (CRT, Anchoring Paradigm) will not be correlated with performance in measures of holistic processing (GCT, AGL, RAT, ACT).

4.1.6.3 Interactions with Personality Traits and Cognitive Ability

Finally, given the conflicting evidence on the relationship between individual traits and intuitive performance tasks, it appears that the association depends on the mechanisms that drive performance in these tasks. According to Sobkow et al. (2018), performance measures of coherence/insight and implicit learning show different patterns of relationships with personality traits, crystallized, and fluid intelligence. While this distinction is promising, we will challenge it by applying Pretz and Totz's (2007; see also Hill, 1987) distinction into heuristic/inferential and holistic intuitive functions. Thus, we hypothesize that the categorization of the instrument as heuristic, holistic semantic, and holistic perceptual moderates the association between the assessed traits (openness, neuroticism, conscientiousness, crystallized and fluid intelligence) and performance in different measures.[5]

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[4] Although this hypothesis was initially preregistered as undirected, we opted to specify the direction of the effect to align with the originally hypothesized absence of positive relationship between self-reported intuitive processing style and objective intuitive performance.

[5] Our original preregistration included an additional hypothesis concerning the moderating role of personality traits between participants' self-assessed (see the following *Methods* section) and objective performance. To keep the scope of this work within reasonable limits,

4.2 Method

4.2.1 Transparency, Ethics, and Sample Size Planning

All analysis scripts, data, and materials have been made publicly available at the Open Science Framework (OSF) and can be assessed at https://osf.io/yw8bc. All measures, manipulations, and exclusion of data (if any) are reported in the methods section. All procedures were performed in accordance with the ethical guidelines of the Declaration of Helsinki, the American Psychological Association, and the Deutsche Gesellschaft für Psychologie. Informed written consent was obtained from participants prior to participation.

A small to medium effect size of $r = .20$ was used as an estimator of the expected and relevant effect sizes. Using G*Power (Faul et al., 2009), the required sample size for a bivariate correlation analysis with a power of .80 was calculated to be $N = 193$. To account for potential no-shows in the second session of the experiment (see below), we planned for a slightly larger sample size than indicated by our power analysis.

4.2.2 Sample

The experiment was conducted in an online setting using *Inquisit Web* (2016). Participants were recruited via the Online-Access-Panel *Prolific Academic* (https://www.prolific.co). Due to the length of the experimental battery, the data assessment was split into two consecutive sessions. Following completion of the first session (mean completion time 53 min), participants were invited to take part in a second session. A total of $N = 219$ participants (125 male, 92 female, 2 gender-diverse; $M_{age} = 29$, $SD_{age} = 9$) completed the second session (mean completion time 39 min). Participants received £12.50

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the testing of this hypothesis was omitted from the present paper but can be found in our Supplementary Materials (see Appendix B).

compensation for both sessions in total. None of the 219 participants met our preregistered exclusion criteria. Thus, all were included in the analyses.

4.2.3 Materials and Procedure

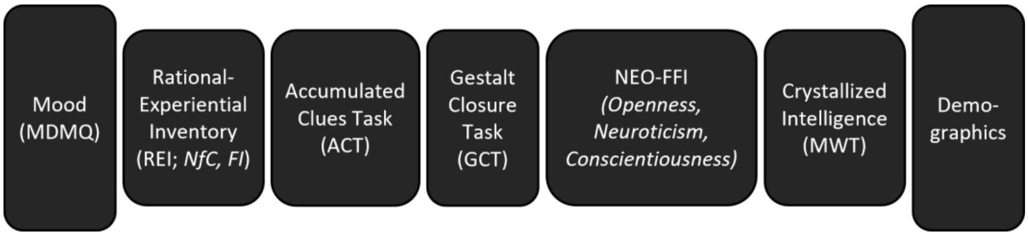
4.2.3.1 Session 1

Before participating in the first session, participants were informed about the multipart structure of the experiment and that the experiment investigated fundamental cognitive processes. To control for the potentially confounding influence of mood, each session started with a mood questionnaire, specifically, the bipolar subscales *good-bad mood* and *calmness-restlessness* from the Multidimensional Mood Questionnaire (MDMQ; Steyer et al., 1997). In the short German version of that measure employed here, each of the two MDMQ scales contained four single-worded items (e.g., “calm”), representing different mood states. Participants were instructed to indicate to what degree each item described their current mood status on a five-point intensity scale from 1 (*not at all)* to 5 (*very*).

After the mood assessment, all measures of session 1 followed in random order re-randomized anew for each participant. The allocation of the instruments between the two sessions was arbitrarily based on the time required to complete each instrument and the variety of tasks within the experimental session to keep participants engaged. Session 1 comprised the REI (self-reported intuitive processing style), the ACT (insight problem-solving), a GCT (visual coherence intuition), three scales from the NEO Five-Factor Inventory (NEO-FFI), and a measure of crystallized intelligence (MWT; see Figure 4.2). Each of the performance measures (i.e., the ACT, GCT, and MWT) was followed by participants’ self-assessment of their own performance in that task on a scale from 0 (*0% accurate*) to 10 (*100% accurate*). All analyses that relate to this self-assessment can be found in the Supplementary Materials (see Appendix B).

Figure 4.2

Experimental procedure of Session 1



Note. Between the initial mood assessment and the demographics, all measures were presented in random order. Designations in italics refer to subscales within an instrument.

Rational-Experiential Inventory (REI). To estimate participants' preference to engage in analytic vs. intuitive processing, the Rational-Experiential Inventory (REI; Epstein et al., 1996; German version, Keller et al., 2000) was employed. All items of the subscales *Need for Cognition* (NfC, 14 items) and *Faith in Intuition* (FI, 15 items) were presented in randomized order (sample item: "I believe in trusting my hunches."). A 7-point-Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*) was applied.

Accumulated Clues Task (ACT). As a measure of insight problem-solving, the Accumulated Clues Task (ACT; Bowers et al., 1990; German version, Löffler & Topolinski, 2023) was employed. Participants were informed that they would be presented with lists of clue words, each of which would imply one solution word. The clues within each list would be presented successively, with each clue increasing in semantic proximity to the respective solution word. Their task would be to generate the correct solution word as soon as possible. Subsequently, 20 word lists (each consisting of 15 clues) were presented in random order with the order of clues within a list held constant for all participants. Sample item: "bone – grinding – crack – quartz – house – glossy – sand – shattering – crystal – mirror – glasses – transparent – shard – window – pane", implying the solution word "glass". Prior to the beginning of each list, participants were informed that they were about to begin a new word list. Then, each clue of a list was presented in capital letters for 2,000 ms. Following each clue, participants were instructed to enter a plausible solution word into a text box, after which the next clue appeared. Participants were encouraged, but not required, to provide a plausible solution word whenever the text box appeared (cf. Löffler & Topolinski, 2023). A new word list started when the correct solution word was typed into the text box (irrespective of capitalization and common misspellings) or when the solution word had not been generated after the 15^{th}, that is, final clue.

Gestalt Closure Task (GCT). For the assessment of visual coherence intuition, a Gestalt Closure Task (GCT; Bowers et al., 1990; stimulus pool by Topolinski & Strack, 2009b) was implemented, consisting of 30 highly degraded black-and-white drawings of everyday objects (coherent) and 30 fragmented versions of these drawings (incoherent). Participants were informed that they would be presented with a series of visually degraded images showing either everyday objects or random visual information. Their task would be to decide whether a particular image showed an actual object or just visual noise. Then, participants were presented with the 30 coherent and 30 incoherent images in random order. According to the experimental procedure of Topolinski and Strack (2009b), each image was presented for 1,000 ms. Following the presentation of each image, the words *non-object* (left side) and *object* (right side) were displayed on the screen, and participants were instructed to evaluate the coherence of the image by pressing either the left (S) or right (L) response key. Subsequently, a text box appeared and participants were asked to type in the name of the object that was depicted in the image, or leave the text box empty if they had not identified any object. This was done to allow elimination of those trials from the analysis in which participants had correctly identified the depicted object, which disqualifies this trial as being intuitive (e.g., Topolinski & Strack, 2009b). Then, the next trial ensued.

Personality Scales (NEO-FFI). Additionally, the subscales *Openness to Experience*, *Neuroticism*, and *Conscientiousness* from the NEO Five-Factor Inventory (NEO-FFI; Costa &

McCrae, 1992; German version, Borkenau & Ostendorf, 1993) were implemented (for a rationale as to why only these three dimensions were included, please refer to our previous section on *Personality Traits*). Each of the three scales consists of 12 items (e.g., "I seldom notice the moods or feelings that different environments produce.") that were assessed on a 7-point-Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Presentation order was re-randomized anew for each participant.

Crystallized Intelligence (MWT). As a measure of crystallized intelligence, the 37 items of the Multiple-Choice Vocabulary Intelligence Test (Mehrfach-Wortschatz-Intelligenztest [MWT]; Lehrl, 2005; exclusively available in German) were administered. Each item in the MWT consists of five words (e.g., "Tuhl – Lar – Lest – Dall – Lid") presented one below the other, only one of which represents an existing German term (in this case "Lid", translated as "lid/cap"); the remaining four words are fictitious constructions mimicking to be words of the German language. The items were arranged according to their level of difficulty, starting with the easiest item, and participants had to indicate the actual German term by clicking on the respective word.

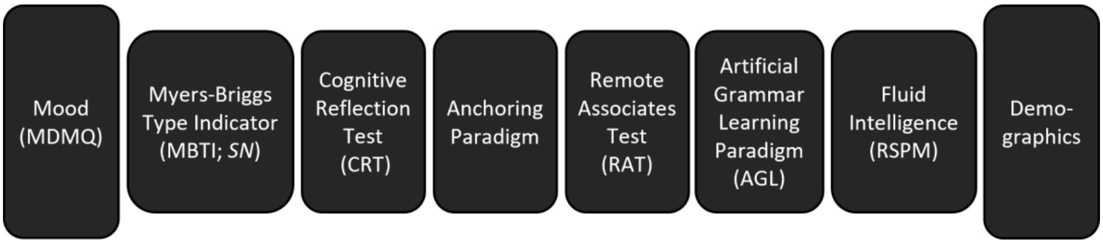
Demographics. After completing all experimental tasks, participants were asked to provide demographic information including their age, gender, highest level of education, and first language. Additionally, they were asked to frankly indicate how much attention they had paid to the experimental tasks on a scale from 1 (*no attention at all*) to 5 (*full attention*). We assured participants that their honest response would not have any negative consequences and would only be used to assess the quality of our data on a global level. Participants then generated a unique identification code for the next session by combining the first letter of their first name, the day of their birth (numerical), and the first letter of the city where they were born.

4.2.3.2 Session 2

Participants were invited to attend the second session four days after participating in Session 1. Starting with the mood assessment, this session contained the Sensing/Intuition (SN) subscale from the MBTI (intuitive processing style), the CRT (a performance measure of heuristic vs. analytic processing), an Anchoring Paradigm, the RAT (semantic coherence intuition and insight problem-solving), an AGL (artificial grammar intuition), and a measure of fluid intelligence (RSPM); see Figure 4.3. The order of these tasks was re-randomized anew for each participant. Again, each of the performance measures (i.e., the CRT, Anchoring Paradigm, RAT, AGL, and RSPM) was followed by participants' self-assessment of their performance in that task (see Supplementary Materials).

Figure 4.3

Experimental procedure of Session 2



Note. Between the initial mood assessment and the demographics, all measures were presented in random order. Designations in italics refer to subscales within an instrument.

Myers-Briggs Type Indicator (MBTI). As measure of intuitive processing style, the bipolar subscale Sensing/Intuition (SN) of the Myers-Briggs Type Indicator (MBTI; Myers, 1962) was employed. The German version (Bents & Blank, 1991) of the SN scale comprises 22 dichotomous items (e.g., "Do you usually get along better with people A] who are imaginative or B] who are realistic"). Participants were asked to indicate the option that described themselves best. All items were presented in randomized order and re-randomized anew for each participant.

Cognitive Reflection Test (CRT). The Cognitive Reflection Test (CRT; Frederick, 2005) was implemented as a performance measure of heuristic vs. analytic processing. The three original items were translated into German and presented sequentially to the participants (sample item: “A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?”). Participants were instructed to enter the solution into a text box located below each question. No response time window was applied.

Anchoring Paradigm. Additionally, participants were presented with six anchoring items adapted from Strack and Mussweiler (1997) to assess their anchoring susceptibility. The task was described to the participants as a knowledge task. According to the procedure of classical Anchoring Paradigms (cf. Englich & Soder, 2009; Jacowitz & Kahneman, 1995; Strack & Mussweiler, 1997), participants were first asked whether a numeric value (anchor) was higher or lower than a particular quantity of interest (e.g., “Was Leonardo da Vinci born before or after 1391?”). Plausible high and low anchor values (also from Strack & Mussweiler, 1997) were implemented and participants randomly received either a high (in this case, “1698”) or a low (“1391”) anchor for the comparative question. Subsequently, participants were asked to provide a precise estimation of the quantity of interest in the absolute question (e.g., “What year was Leonardo da Vinci born?”). After completing the task, participants were asked to answer six additional questions to control for their prior knowledge regarding the anchoring questions (e.g., “How good is your general knowledge about the life of Leonardo da Vinci?”). A 5-point scale from 1 (*no knowledge at all*) to 5 (*high knowledge*) was applied.

Remote Associates Test (RAT). For the assessment of semantic coherence intuition, we employed 36 coherent (e.g., “salt – deep – foam” implying “sea”) and 36 incoherent (e.g., “dream – ball – book”) word triads from the German stimulus pool of Bolte and Goschke (2005). Prior to the main task, participants were trained to respond within a given time window of 2,000 ms (cf. Bolte & Goschke, 2005; Topolinski & Strack, 2009b). After participants had completed this training, they were introduced to the concept of coherent (in German referred to as *zusammenhängend* [interrelated]) and incoherent word triads (referred to as *zusammengewürfelt* [mixed]; cf. Topolinski and Strack, 2009b). They were briefed that the subsequent task would involve evaluating word triads, which could either share a common associate or be randomly mixed together. Their task would be to evaluate whether a given word triad was interrelated or mixed. Subsequently, participants were introduced to three examples of coherent and incoherent triads (retrieved from a different stimulus set; see Beeman et al., 1994) and trained to respond to these example triads within a time window of 2,000 ms. In the course of the following main task, each trial was initiated by a fixation cross that appeared in the center of the screen for 1,000 ms. Then, a word triad was randomly sampled from the stimulus pool (re-randomized anew for each participant) and presented for 1,500 ms. After that word triad had disappeared, the words *mixed* (left side) and *interrelated* (right side) were displayed on the screen, and participants were instructed to evaluate the coherence of the word triad by pressing either the left (S) or right (L) response key. If no key was pressed within a time window of 2,000 ms, the message “Too slow” was displayed, and the next trial ensued. Upon successfully responding within the designated time window, participants were prompted to enter a potential solution word for the given triad into a text box. This was to control for explicit insights into the solution concepts, which would disqualify the trial as being intuitive. If participants could not think of a solution word, they were instructed to leave the text box blank.

Artificial Grammar Learning Paradigm (AGL). Further, an artificial grammar learning paradigm (AGL; Reber, 1967) was implemented, employing the stimulus pool by Vokey and Brooks (1992). Similar to the procedure of Kinder et al. (2003), participants were first trained to reproduce 16 study strings that conformed to a complex artificial grammar. Each study string, consisting of three to seven capitalized letters, was presented individually on the screen and participants were instructed to memorize it. Following a self-paced memorization phase, participants were instructed to press a key, and the letter string disappeared. Participants were then asked to correctly reproduce the memorized string in a text box. If the string was correctly reproduced, the next letter string was displayed. If participants were unable to reproduce the string, the message “Please try again” was displayed, and the string in question was repeated until it was reproduced correctly. The training continued until participants had correctly reproduced each of the 16 study strings three times. In the subsequent test phase, participants were informed that all study strings had conformed to an implicit grammatical rule. Their subsequent task would be to evaluate whether the subsequently presented letter strings conformed to the same implicit rule or were randomly constructed. Then, 16 grammatical and 16 agrammatical novel strings (consisting of three to seven letters) were presented in randomized order. Strings were presented in the center of the screen, along with the words *no rule* on the left and *rule* on the right side. Participants indicated the string's grammaticality by pressing the left or right response key, whereupon the next string appeared. The task was self-paced.

Fluid Intelligence (RSPM). Participants were administered a 9-item short form (Bilker et al., 2012) of the Raven’s Standard Progressive Matrices Test (RSPM; Raven et al., 2000). The items were arranged according to their level of difficulty, starting with the easiest.

Demographics. After completing all experimental tasks, participants were asked to provide their demographic information. They were also asked to report the level of attention they had devoted to the tasks (see *Session 1*). Finally, participants generated the same personal identification code used in Session 1 and were thanked for their participation.

4.3 Results

The data were analyzed using IBM SPSS Statistics and R. All reported p-values correspond to two-sided tests. In the following sections, we will not report the measures in the same order as in the method section, which resulted from the arbitrary division of tasks into two sessions. Instead, we will report them in a conceptually plausible order according to our hypotheses.

4.3.1 Data Preparation and Exclusion

Reverse-poled items in the Sensing/Intuition (MBTI), Need for Cognition, and Faith in Intuition (REI) subscales were recoded, respectively, and scale means were computed.

Performance in the CRT was operationalized as the percentage of correctly solved items. Additionally, we calculated the percentage of intuitive responses (for the scoring procedure, see Erceg & Bubić, 2017) as well as the percentage of responses that were neither correct nor intuitive.

Regarding the anchoring paradigm, trials in which participants reported having significant knowledge about the subject of the questions (30 out of 1,314 trials, 2.28%; corresponding to a score of 5 on the knowledge scale; see *Materials and Procedure, Session 2*), and responses that exceeded three standard deviations from the mean (extreme outliers; 15 out of 1,284 trials, 1.17%) were discarded (see preregistration). To quantify the overall magnitude of participants' anchoring bias, individual anchoring scores were calculated as follows (cf. Cheek & Norem, 2017; Epley& Gilovich, 2001; Simmons et al., 2010):[6] First, we

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[6] Contrary to the procedure specified in our preregistration, we did not compute an Anchoring Index according to the procedure of Jacowitz and Kahneman (1995), since this index is designed to measure the global anchoring effect of a whole sample, and, on closer inspection, did not serve our specific research question on individual differences.

calculated the absolute value of the difference between each individually given estimate and the presented high or low anchor value. We then converted these values into z-scores. Then, we calculated the average of these z-scored values for each participant and condition (high anchor values/low anchor values). The resulting anchoring scores reflect the mean distance between participants' estimates and the presented numerical anchors, with higher scores indicating a larger gap between estimates and anchors (cf. Simmons et al., 2010).

For the ACT, performance scores were calculated based on the number of clues that were required to infer the correct solution word (cf. Löffler and Topolinski, 2023). For better interpretation, the number of required clues (smaller scores indicating faster solution performance) was reverse-coded so that higher scores indicated higher (i.e., faster) solution performance, with the resulting performance score ranging from 1 (lowest possible performance) to 15 (highest possible performance).[7] Only the solution word itself and its plural form were accepted as correct. Word lists for which the solution word was not inferred by the 15th (i.e., final) clue were scored as unsolved.

Additionally, all trials from the RAT in which the response had not been generated within the time window of 2,000 ms were discarded (945 out of 15,768 trials, 6%; see preregistration).[8] From the remaining trials, coherent trials in which participants had indicated the correct solution concept were used as a secondary measure of insight problem-solving (959 out of 7,394 trials, 12.97%; cf. Bolte & Goschke, 2005; Bowers et al., 1995). Not only the solution word itself and exact synonyms of the solution word were accepted, but also

[7] Scoring procedure: 1 clue = 15, 2 clues = 14, 3 clues = 13, 4 clues = 12, 5 clues = 11, 6 clues = 10, 7 clues = 9, 8 clues = 8, 9 clues = 7, 10 clues = 6, 11 clues = 5, 12 clues = 4, 13 clues = 3, 14 clues = 2, 15 clues = 1.

[8] Of these, 6.22% (490 out of 7,884) were coherent and 5.77% (455 out of 7,884) were incoherent trials.

alternative solution words that made meaningful reference to all three words of the triad (e.g., "*Christmas Eve*" instead of "*candle*" for the triad "church – light – birthday"; cf. Bolte & Goschke, 2005; Topolinski and Strack, 2009b). From the remaining unsolved trials, hit and false alarm rates were calculated (see following section).

In the GCT, we discarded coherent trials in which participants had correctly identified the depicted object or had suggested objects of extreme visual similarity (e.g., *mandolin* instead of *banjo*; 58 out of 6,570 trials, 0.88%; cf. Topolinski and Strack, 2009b). From the remaining trials, hit and false alarm rates were calculated. The AGL paradigm did not require discarding explicitly solved trials. Thus, hit and false alarm rates (see following section) were calculated based on all presented trials.

For the MWT and RSPM as measures of crystallized and fluid intelligence, the percentage of correctly solved items was calculated to reflect the individual performance. For the NEO-FFI scales, reverse-poled items were recoded and scale means were computed.

4.3.1.1 Hit and False Alarm Rates

For the RAT, GCT, and AGL, hit rates (i.e., the proportion of coherent/grammatical trials that were correctly identified as being coherent/grammatical) and false alarm rates (i.e., the proportion of incoherent/agrammatical trials that were incorrectly identified as being coherent/grammatical) were computed according to signal detection theory (see e.g., Wickens, 2001). Then, intuitive accuracy was calculated as the difference between hits and false alarms (cf. Baumann & Kuhl, 2002; Bolte et al., 2003; Kinder et al., 2003; Topolinski & Strack, 2009b). This derivative measure can range from -1 to 1, with positive values indicating a successful intuitive discrimination.

4.3.2 Descriptive Statistics

4.3.2.1 Control Variables

When controlling for the potentially confounding influence of mood state, neither participants' mood ($M_{Session1}$ = 3.86, $SE_{Session1}$ = 0.05; $M_{Session2}$ = 3.82, $SE_{Session2}$ = 0.06), $t(218)$ = 0.77, p = .445, d_z = 0.05, 95% CIdifference = [-0.06, 0.15], nor participants' calmness ($M_{Session1}$ = 3.67, $SE_{Session1}$ = 0.06; $M_{Session2}$ = 3.68, $SE_{Session2}$ = 0.06), $t(218)$ = 0.25, p = .802, d_z = 0.02, 95% CIdifference = [-0.13, 0.10], differed between the two sessions. Further, although potentially biased by social desirability, participants reported paying nearly full attention to the experimental tasks ($M_{Session1}$ = 4.83, $SD_{Session1}$ = 0.40; $M_{Session2}$ = 4.81, $SD_{Session2}$ = 0.45) on the applied scale from 1 to 5.

4.3.2.2 Intuitive Performance Tasks

In the CRT (cognitive reflection), on average 64.23% (*SD* = 36.60; 1.93 out of 3) of the items were solved correctly, whereas participants provided the intuitive, incorrect response for 29.07% (*SD* = 31.64; 0.87 out of 3) of the items. The remaining 6.70% (*SD* = 15.17; 0.20 out of 3) items were neither solved correctly nor intuitively.

In the ACT (insight problem-solving), participants solved a total of 74.46% (*SD* = 21.34) of the 20 word lists with the correct solution word, requiring an average of 8.95 (*SD* = 1.23) clues per list (corresponding to a reverse-coded performance score of 7.05).

In the RAT, 12.97% (959 out of 7,394 trials) were classified as insight problem-solving, as participants reported the correct solution concept. As shown in Table 4.1, the sample as a whole showed highly significant intuitive discrimination in semantic coherence (RAT), visual coherence (GCT), and artificial grammar intuition (AGL).

Table 4.1

Hit rates, false alarm rates, intuitive accuracies, and paired samples t-tests between hit and false alarm rates in semantic coherence, visual coherence, and artificial grammar intuition

	Hit		False Alarm		Intuitive Accuracy					
	M	*SE*	*M*	*SE*	*M*	*SD*	*t*	*p*	d_z	*95% CI*
RAT: Semantic Coherence Intuition	.41	.01	.28	.01	.13	.14	14.21	< .001	0.96	0.12 – 0.15
GCT: Visual Coherence Intuition	.31	.01	.16	.01	.15	.12	17.98	< .001	1.22	0.13 – 0.17
AGL: Artificial Grammar Intuition	.64	.01	.48	.01	.17	.15	16.77	< .001	1.13	0.15 – 0.19

Note. $N = 219$. Hit and False Alarm Rate ranging from 0 to 1 with increasing values indicating a higher percentage of Hits/False Alarms; Intuitive Accuracy ranging from -1 to 1 with positive (increasing) values indicating increasingly successful discrimination. d_z = effect size for within-subjects t-tests.

4.3.3 Hypotheses

Table 4.2 presents the means, standard deviations, bivariate correlations, and internal reliabilities (Cronbach's Alpha) of and among the examined measures. To investigate the associations between the measures, their averaged performance scores and scale means were intercorrelated using Pearson product-moment coefficients. To counteract the problem of multiple testing, Bonferroni correction was employed. As robustness check for the null hypotheses, we will also report uncorrected significance as secondary measures and will refer to Bonferroni corrected significance levels as p_1 and to uncorrected significance levels as p_2.

Table 4.2

Means, standard deviations, bivariate correlations (Bonferroni corrected; see uncorrected significance levels [in square brackets]) with internal consistency reliabilities (Cronbach's Alpha) in the diagonal

		M	*SD*	1	2	3	4a	4b	5	6a	6b	7	8	9	10	11	12	13	14
1	MBTI: Sensing/Intuition (SN) [a]	1.59	0.23	(.83)															
2	REI: Need for Cognition (NfC) [b]	5.14	1.02	.26**	(.90)														
3	REI: Faith in Intuition (FI) [b]	4.20	0.86	.02	-.30**	(.86)													
4a	CRT: Correct Response (Percentage)	64.23	36.60	-.01	.27**	-.34**	(.66)												
4b	CRT: Intuitive Response (Percentage)	29.07	31.64	.01	-.23**	.30**	-.91**	(.53)											
5	Anchoring Susceptibility [c]	0.00	0.47	.05	.02	.05	.01	-.00	(.27)										
6a	RAT: Semantic Coherence Intuition (Accuracy) [d]	0.13	0.14	-.01	.05	-.11	.07	-.05	-.00	(.85)									
6b	RAT: Insight Problem-Solving (Solved, Percentage)	12.97	9.03	.04	.13	-.18[**]	.15[*]	-.11	.09	.21*[**]	(.68)								
7	ACT: Insight Problem-Solving (Performance Score) [e]	7.05	1.23	.10	.25**	-.16[*]	.20[**]	-.20[**]	.10	.11	.29**	(.77)							
8	GCT: Visual Coherence Intuition (Accuracy) [d]	0.15	0.12	.07	.05	-.01	.12	-.11	-.04	.17[*]	.15[*]	.10	(.92)						
9	AGL: Artificial Grammar Intuition (Accuracy) [d]	0.17	0.15	-.00	.08	.01	.09	-.11	.04	.14[*]	.07	.08	.11	(.60)					
10	MWT: Crystallized Intelligence (Percentage)	68.73	12.31	.09	.24**	-.06	.13	-.16[*]	-.02	.21*[**]	.22*[**]	.30**	.11	.09	(.85)				
11	RSPM: Fluid Intelligence (Percentage)	80.37	19.20	.07	.22*[**]	-.20*[**]	.40**	-.37**	-.05	.15[*]	.28**	.26**	.13	.12	.22*[**]	(.64)			
12	NEO-FFI: Openness [b]	5.19	0.77	.50**	.46**	-.07	.09	-.13	.01	.15[*]	.20*[**]	.20[**]	.14[*]	.12	.23**	.12	(.71)		
13	NEO-FFI: Neuroticism [b]	4.11	1.29	.13	-.24**	-.15[*]	-.01	-.04	-.04	-.02	.04	-.08	.03	.06	.03	.05	.08	(.91)	
14	NEO-FFI: Conscientiousness [b]	4.71	1.01	-.24**	.29**	.18[**]	-.08	.12	.04	.08	.05	-.01	.06	-.05	-.04	-.02	.01	-.49**	(.87)

Note. $N = 219$. [a] 1 = Sensing, 2 = Intuition; [b] 1 = strongly disagree – 7 = strongly agree; [c] averaged z-scored distance between participants' estimates and the presented anchors (anchoring scores); [d] Intuitive accuracy in the respective measure ranging from -1 to 1 with positive (increasing) values indicating (increasingly) successful discrimination; [e] 1 = lowest possible performance – 15 = highest possible performance. * $p < .05$, ** $p < .01$.

4.3.3.1 Questionnaires

Replicating previous evidence (Edwards et al., 2002; Pretz & Totz, 2007; Topolinski & Hertel, 2007), we found a weak positive correlation between the SN subscale (MBTI) and the NfC subscale (REI), $r(217) = .26$, $p_1 = .002$, indicating that the higher participants' propensity for abstract and imaginative reasoning, the higher also their propensity for intellectual engagement. However, in accordance with Edwards et al. (2002) and Pretz and Totz (2007), the MBTI's SN scale and the REI's FI scale as actual measures of *intuitive* processing style were uncorrelated, $r(217) = .02$, $p_2 = .810$, suggesting that they tap distinct aspects of intuitive processing style or even different constructs.

4.3.3.2 Holistic Performance Tasks

The predicted positive correlation between discrimination accuracy in semantic coherence intuition (RAT) and solution performance in insight problem-solving (ACT) was not observed, $r(217) = .11$, $p_2 = .116$ (contradicting previous findings by Bowers et al., 1995). However, insight into the solution concepts of the RAT (secondary measure) was positively associated with insight problem-solving in the ACT, $r(217) = .29$, $p_1 < .001$, suggesting that the more frequent participants had spontaneous insights into the solution concepts of the RAT's triads, the faster they were able to narrow down the solution words in the ACT.

Further, the intuitive discrimination accuracy in visual coherence intuition (GCT) and artificial grammar intuition (AGL) was uncorrelated, $r(217) = .11$, $p_2 = .120$, suggesting that they rely on different cognitive mechanisms.

4.3.3.3 Questionnaires and Performance Tasks

Replicating Langan-Fox and Shirley (2003), the SN scale (MBTI) was not correlated with any performance measure (all $p_2s > .142$), suggesting that it may measure a different dimension of intuition or even a different construct.

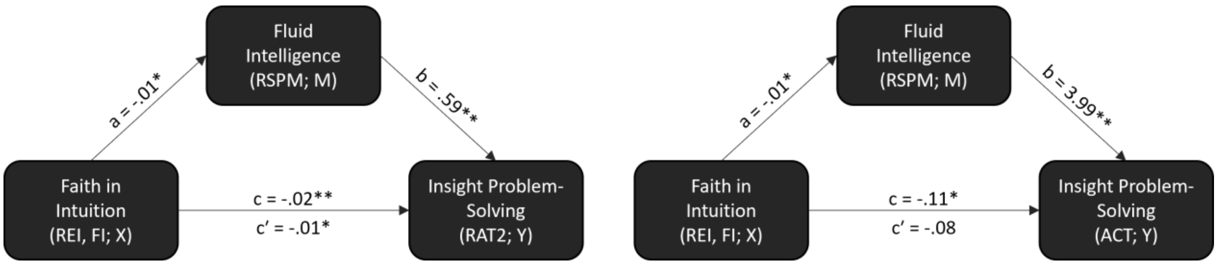
The FI scale (REI) was moderately negatively correlated with the number of correct responses in the CRT, $r(217) = -.34$, $p_1 < .001$, as well as prior to Bonferroni correction, weakly negatively correlated with insight problem-solving in the RAT (secondary measure), $r(217) = -.18$, $p_1 = .113$, $p_2 = .007$, and ACT, $r(217) = -.16$, $p_1 = .284$, $p_2 = .018$. This suggests that the greater participants' overall faith in their intuitive hunches, the worse they performed in the CRT, as they more frequently reported heuristic responses (which is in line with Pennycook et al., 2016). Further, the higher participants faith in intuition, the fewer word triads they spontaneously solved in the RAT and the more clues they required to solve the ACT's word lists (which replicates Reber et al., 2007).

Additional regression analyses (using the PROCESS macro for SPSS, model 4; Hayes, 2018) revealed that the relationship between faith in intuition and insight problem-solving in the RAT/ACT was largely mediated by fluid intelligence. This was evidenced by the reduced and nearly nonsignificant ($p = .048$) direct effect of FI on the RAT (indicating partial mediation) and the nonsignificant direct effect of FI on the ACT (indicating full mediation) after accounting for the mediating effect of fluid intelligence (see Figure 4.4 below).

Thus, after controlling for the influence of fluid intelligence, faith in intuition was merely associated with an increased reliance on spontaneous intuitive hunches (worse performance in the CRT), whereas the association with insight problem-solving in the RAT and ACT was largely driven by fluid intelligence.

Figure 4.4

Mediating effect of fluid intelligence on the relationship between faith in intuition (REI; FI) and semantic insight problem-solving in the RAT (left, partial mediation) and ACT (right, full mediation)



Note. RAT2 refers to our secondary measure in the Remote Associates Test, indicating the percentage of solved triads. a, b = indirect effect; c = total effect; c' = direct effect. * $p < .05$, ** $p < .01$.

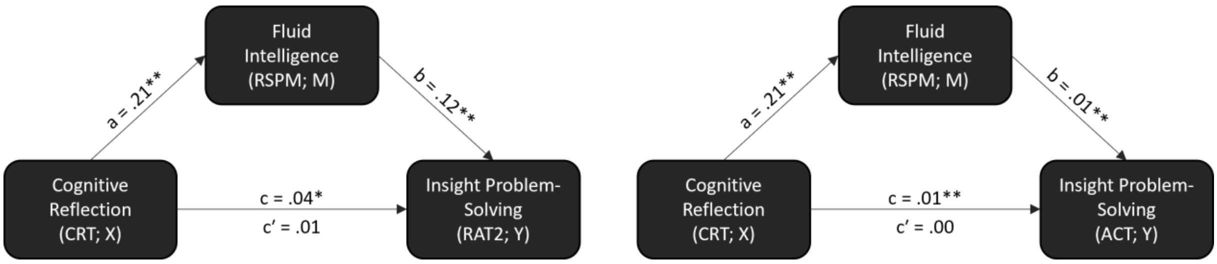
4.3.3.4 Heuristic and Holistic Performance Tasks

Regarding the correlations among heuristic (i.e., CRT and Anchoring Paradigm) and holistic performance tasks (i.e., RAT, ACT, GCT, and AGL), cognitive reflection in the CRT did not relate substantially to any of the holistic tasks after Bonferroni correction. However, when uncorrected, it was weakly correlated with insight problem-solving in the RAT (secondary measure), $r(217) = .15$, $p_1 = .405$, $p_2 = .025$, and ACT, $r(217) = .20$, $p_1 = .06$, $p_2 = .003$. That is, the more items in the CRT that participants solved correctly through cognitive reflection, the more frequent they had spontaneous insights into the solution concepts of the RAT's triads, and the faster they were able to narrow down the solution word of the ACT's word lists. Further regression analyses revealed that these relationships between CRT performance and insight problem-solving in the RAT/ACT were both fully mediated by fluid intelligence, as evidenced by the nonsignificant direct effect of the CRT on the RAT and ACT after accounting for the mediating effect of fluid intelligence (see Figure 4.5 below).

Susceptibility to the anchoring effect did not significantly relate to any of the holistic measures, even before the Bonferroni correction (all $p_2s > .145$). Thus, in support of our hypothesis, cognitive reflection in the CRT and susceptibility to the anchoring effect were not significantly correlated with any of the holistic measures after accounting for the influence of fluid intelligence.

Figure 4.5

Mediating effect of fluid intelligence on the relationship between cognitive reflection (CRT) and semantic insight problem-solving in the RAT (left) and ACT (right)



Note. RAT2 refers to our secondary measure in the Remote Associates Test, indicating the percentage of solved triads. a, b = indirect effect; c = total effect; c' = direct effect. * $p < .05$, ** $p < .01$.

4.3.3.5 Interactions with Personality Traits and Cognitive Ability

To further evaluate the associations between the traits (i.e., openness, neuroticism, conscientiousness), intelligence measures (i.e., crystallized intelligence, and fluid intelligence), performance measures, and the measures's categorization (i.e., heuristic, holistic semantic, and holistic perceptual), we ran a linear mixed-effect model in R employing the lme4 package (Bates et al., 2015). To standardize the performance in different measures, performance scores were each converted into z-scores. The model included performance in different measures as criterion (i.e., GCT, AGL, RAT, ACT, CRT, and Anchoring Paradigm;

repeated measure, computed using centered variables) and the remaining factors (i.e., traits and instrument categorizations; all computed using centered variables) as fixed effects. To account for individual variability, random intercepts for participants were included.

The analysis yielded significant main effects of crystallized intelligence, $b = 0.01$, $t = 2.74$, $p < .01$, 95% CIdifference = [0.00, 0.01], fluid intelligence, $b = 0.01$, $t = 4.46$, $p < .01$, 95% CIdifference = [0.00, 0.01], and openness, $b = 0.11$, $t = 2.72$, $p < .01$, 95% CIdifference = [0.03, 0.19], indicating that these factors were positively associated with intuitive performance. The effects of the categorizations and the remaining personality traits were not significant (all *ps* > .429). The overall variability between participants' performance was low (potentially due to the low correlations between the measures), as suggested by the random effects (*SD* = 0.22).

Adding the interactions between the traits and instrument categorizations to the model, additionally revealed an interaction between the holistic semantic categorization and crystallized intelligence, $b = 0.02$, $t = 2.76$, $p < .01$, 95% CIdifference = [0.00, 0.03]. This suggests that higher crystallized intelligence predicted higher performance scores in the RAT (semantic coherence intuition) and ACT (insight problem solving). The remaining interaction terms were non-significant (all *ps* > .186).

Comparison of the first model to the second model, which included the interaction terms, yielded a minimally lower AIC (Akaike's Information Criterion) for the first model ($AIC_{model1} = 3662.5$, $AIC_{model2} = 3665.2$), indicating that the first model was more parsimonious. Additionally, the BIC (Bayesian Information Criterion) was also lower for the first model ($BIC_{model1} = 3714.2$, $BIC_{model2} = 3768.7$). These results suggest that adding the interaction terms did not significantly improve model fit (main test for the hypothesis) and we consider the first model to be the more parsimonious model for this analysis.

4.3.4 Exploratory Analyses

4.3.4.1 Confirmatory Factor Analysis

To test whether we could support Sobkow et al.'s (2018) distinction between measures of subjective intuitive abilities, coherence/insight, and implicit learning, a confirmatory factor analysis (CFA) was conducted in R employing the lavaan package (Rosseel, 2012). Since the factor structure suggested by Sobkow et al. (2018) did not include heuristic tasks, and the CRT and Anchoring Paradigm were unrelated in all of our previous analyses, they were not included in the model. Again, all scores on the remaining measures were converted into z-scores before being entered into the structural model.

A first model included the MBTI's SN and the REI's FI scale, as measures of *subjective intuitive abilities*; both RAT scores, the ACT, and the GCT as measures of *coherence/insight*; and the AGL as measure of *implicit learning* (cf. Sobkow et al., 2018). This model had a poor fit to the data, $\chi2$ (775) = 1295.65, $p < .001$; CFI = .74; TLI = 0.73; AIC = 23964.28; BIC = 24255.34; RMSEA *(pclose)* > .05 ($p = .045$), 90% CIdifference = [0.05, 0.06]; SRMR = .08. Only the path coefficients within the *coherence/insight* factor were significant (all *ps* < .011), indicating that the full factor structure of Sobkow et al. (2018) does not match our present set of instruments. Since the MBTI's SN and the REI's FI scale were completely unrelated, this factor was excluded from the analysis. As the only available measure of *implicit learning*, the AGL was also excluded.

Therefore, a single-factor model was computed, including all measures of *coherence/insight* (i.e., semantic coherence intuition in the RAT, insight problem-solving in the RAT, insight problem-solving in the ACT, and visual coherence intuition in the GCT). The model had a good fit to the data, $\chi2$ (2) = 2.33, $p = .311$; CFI = .99; TLI = 0.97; AIC =

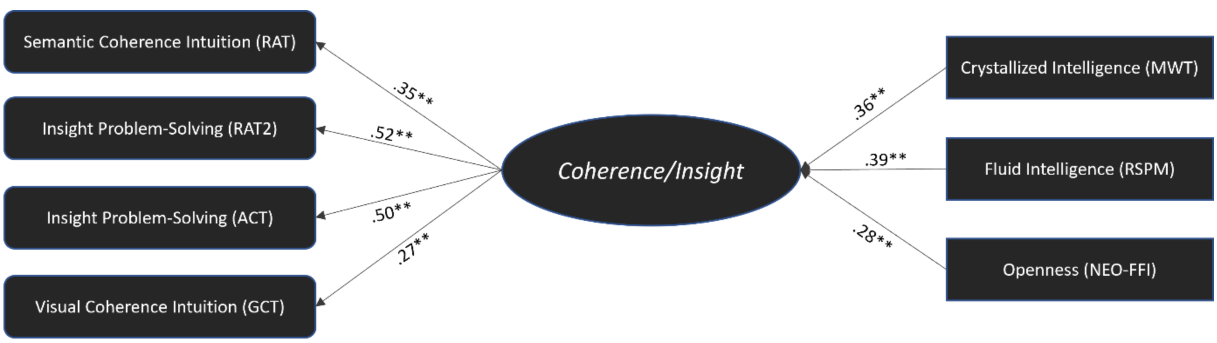
2453.18; BIC = 2480.26; RMSEA *(pclose)* < .05 (*p* = .488), 90% CIdifference = [0.00, 0.14]; SRMR = .03. Importantly, all path coefficients were significant (all *ps* < .029), suggesting that each of the measures included in the analysis contributed to the latent factor of *coherence/insight*.

4.3.4.2 Relationship with Intelligence and Openness

A further structural equation model was computed based on the previous model, additionally including crystallized intelligence (MWT), fluid intelligence (RSPM), and openness to experience (NEO-FFI) as predictors. The model had good fit to the data, $\chi 2$ (11) = 6.45, *p* = .842; CFI = 1.00; TLI = 1.09; AIC = 2400.99; BIC = 2438.22; RMSEA *(pclose)* < .001 (*p* = .972), 90% CIdifference = [0.00, 0.04]; SRMR = .03. Thus, replicating Sobkow et al. (2018), the coherence/insight factor was significantly predicted by crystallized intelligence (β = .36, *p* < .001), fluid intelligence (β = .39, *p* < .001), and openness (β = .28, *p* = .003). This suggests that each of these traits contributes to the efficiency of coherence judgments and insight (see Figure 4.6 below).

Figure 4.6

Relationships between single-factor model of coherence/insight and individual traits



Note. Standardized path coefficients. * *p* < .05, ** *p* < .01.

4.3.4.3 Principal Components Analysis

To examine the overlapping variance of all measures, their averaged performance scores and scale means were entered into a principal components factor analysis (PCA) with orthogonal rotation (varimax). Based on a scree-test, seven factors were extracted explaining 68.54% of the total variance (12.31%, 11.99%, 11.55%, 11.30%, 7.16%, 7.15%, and 7.08% for factors 1, 2, 3, 4, 5, 6, and 7, respectively). Although lower than optimal, sampling adequacy was confirmed by the Kaiser-Meyer-Olkin measure (KMO = .61). Bartlett's test of sphericity was significant, $\chi 2(105) = 526.43$, $p < .001$, which provides further support for the factorability of the data. The results of the orthogonally rotated solution are displayed in Table 4.3 below.

Table 4.3

Orthogonally rotated component loadings of the assessed instruments

Component	1	2	3	4	5	6	7
CRT: Cognitive Reflection	**.806**	.013	.005	-.027	.067	.068	.138
REI: Faith in Intuition (FI)	**-.706**	-.028	.161	-.111	.099	.091	.182
RSPM: Fluid Intelligence	**.589**	.035	-.006	.299	-.012	.111	.183
MBTI: Sensing/Intuition (SN)	-.036	**.832**	-.230	-.016	.082	-.055	.059
NEO-FFI: Openness	.039	**.829**	.018	.212	-.029	.076	.086
REI: Need for Cognition (NfC)	**.451**	**.581**	**.469**	.114	-.050	.045	-.144
NEO-FFI: Conscientiousness	-.115	-.059	**.861**	.046	.003	-.017	.100
NEO-FFI: Neuroticism	.027	.068	**-.819**	.033	-.048	.043	.047
MWT: Crystallized Intelligence	.037	.184	-.035	**.714**	-.149	.048	-.101
RAT: Insight Problem-Solving	.195	-.001	-.036	**.624**	.254	-.170	.235
RAT: Semantic Coherence Intuition	-.021	-.049	.083	**.571**	-.167	.371	.152
ACT: Insight Problem-Solving	.279	.155	.064	**.545**	.297	-.041	-.024
Anchoring Susceptibility	-.055	.016	.039	.011	**.914**	.066	-.051
AGL: Artificial Grammar Intuition	.070	.038	-.072	.027	.084	**.926**	.034
GCT: Visual Coherence Intuition	.076	.094	.026	.084	-.055	.058	**.916**

The first factor (12.31% of the total variance) was constituted by cognitive reflection (CRT), fluid intelligence, and, negatively, faith in intuition (REI), characterizing it as genuine global factor of *reflection*. The second factor (11.99% of the total variance) comprised sensing/intuition (MBTI), openness (NEO-FFI), and with lower and rather ambiguous factor loading, need for cognition (REI), suggesting it to be a factor of *abstract unconventional thinking*. The third factor (11.55% of the total variance) was characterized by conscientiousness and, with negative loading, neuroticism (both from the NEO-FFI), representing a personality dimension of *functional adjustment*. The fourth factor (11.30% of the total variance) comprised all holistic semantic tasks (i.e., both scores of the RAT and the ACT) as well as crystallized intelligence, suggesting it to be a factor of *semantic coherence perception and insight*. The fifth factor (7.16% of the total variance) included the ability to correct for the anchoring bias, the sixth factor (7.15% of the total variance) included artificial grammar intuition (AGL), and the seventh factor (7.08% of the total variance) was formed by visual coherence intuition in the GCT (which contradicts our CFA; see previous section), suggesting that these measures are relatively independent.

4.4 Discussion

In the present article, we explored the associations between various instruments used to assess intuitive functions and their relationships with personality traits and cognitive abilities. Given the heterogeneous patchwork of measurement approaches employed in the field, our findings emphasize the significance of distinguishing between different types of intuitive processes. However, while there is no unified construct of intuition, and some of the evaluated instruments appear to capture relatively independent functions, our findings indicate that there is convergent validity among certain instruments.

While the self-report scales (i.e., the SN scale from the MBTI and the FI scale from the REI) did not exhibit any association with each other, faith in intuition (FI; REI) was negatively associated with several measures of intuitive performance. Specifically, higher faith in intuition was negatively correlated with the ability to override spontaneous hunches in the CRT and, before applying Bonferroni correction, negatively correlated with semantic insight problem-solving in the RAT (secondary measure) and ACT, with the latter two effects largely driven by the mediating influence of fluid intelligence (which was also negatively associated with FI).

Apart from the negative association with faith in intuition, cognitive reflection in the CRT was positively linked to fluid intelligence and need for cognition, which emphasizes its suggested role as a measure of heuristic vs. rational thinking (e.g., Erceg & Bubić, 2017; Pennycook et al., 2016; Toplak et al., 2011). Susceptibility to the anchoring heuristic was not significantly related to any measure in the experimental battery. This supports the notion that the anchoring effect is a cognitively encapsulated phenomenon that is independent of other cognitive processes, personality traits, and cognitive abilities (e.g., Furnham et al., 2012; Stanovich & West, 2008).

Regarding the holistic performance tasks, confirmatory factor analysis (CFA) revealed a factor of coherence and insight (replicating part of the factor structure of Sobkow et al., 2018). Semantic coherence intuition (RAT), semantic insight problem-solving (RAT and ACT), and visual coherence intuition (GCT) all loaded significantly onto this factor. Further, the factor was significantly predicted by crystallized intelligence, fluid intelligence, and openness to experience. In contrast, artificial grammar intuition (AGL) was largely independent of the remaining instruments, as well as of personality traits and cognitive ability.

4.4.1 Questionnaires

Although the overall lack of correlation between the MBTI's SN and the REI's FI subscales is noteworthy, it replicates the findings of Edwards et al. (2002) and Pretz and Totz (2007), suggesting that these two scales are designed to measure quite different concepts of intuitive processing style. The SN scale's association with need for cognition (*r* = .26) and openness to experience (*r* = .46; which replicates Sobkow et al.'s proposed association with subjective intuitive abilities; see also Furnham et al., 2003; Langan-Fox & Shirley, 2003; McCrae & Costa, 1989) characterize SN as a measure of abstract unconventional thinking, which is in line with Langan-Fox and Shirley (2003) and Topolinski and Hertel (2007). In contrast, the FI scale appears to capture a tendency to rely on spontaneous affective hunches (Pretz & Totz, 2007), shallow heuristic processing, and possibly even naïve optimism (Epstein et al., 1996). This tendency is not only reflected in the negative correlation between FI and CRT performance (*r* = -.34; which replicates Pennycook et al., 2016), but also in the negative correlation between FI and our measure of fluid intelligence (*r* = -.20). Although this correlation with intelligence is not consistently observed (Alaybek et al., 2021), it may indicate overoptimism and lack of constructive strategies (cf. Epstein et al., 1996) rather than a lower level of cognitive ability per se. Moreover, contrary to Sobkow et al.'s hypothesis that measures of subjective intuitive ability tend to be associated with openness to experience, and also contrary to previous research supporting this relationship (e.g., Alós-Ferrer et al., 2016; Keller et al., 2000; Pacini & Epstein, 1999; Reber et al., 2007; Witteman et al., 2009), we found no relationship between FI and openness in our present experiment.

4.4.2 Performance Measures

While we cannot support Sobkow et al.'s (2018) factor of subjective intuitive abilities, suggesting that it cannot be generalized to our current set of questionnaires, we can confirm their finding that measures of coherence and insight correspond to one factor that is predicted by crystallized intelligence, fluid intelligence, and openness to experience. This is particularly noteworthy because we employed a different set of instruments than those used in the original experiment by Sobkow and colleagues (2018). Taken together, this evidence supports the classical conceptual framework of Bowers et al. (1995; see also Öllinger & von Müller, 2017), which suggests that coherence perception is guided by an implicit accumulation of clues that may spontaneously emerge into consciousness as a sudden insight. In simpler terms, the theoretical framework that coherence perception is an antecedent of insight might offer a viable explanation for why measures of coherence and insight load on the same factor and are predicted by the same traits.

The results of our principal components factor analysis (PCA) largely align with our CFA, though they do raise questions about the role of the Gestalt Closure Task (visual coherence intuition) within the coherence/insight factor. Considering that the GCT exhibited the lowest loading on the coherence/insight factor in the CFA and was generally not correlated with intelligence, this ambiguous result could be due to the GCT relying on visual Gestalt perception rather than the processing of semantic stimuli (as the remaining measures in this factor do). However, given that Sobkow et al. (2018) also employed the RAT along with an image recognition task, it is also conceivable that this inconsistent finding is due to a low proportion of variance between our instruments (as indicated by our comparatively low sampling adequacy in the PCA; KMO = .61), or possibly even to insufficient validity of the GCT. Further research is needed to determine whether distinguishing between semantic and visual measures—or even between coherence and insight—can meaningfully differentiate the underlying processing mechanisms and their relationship with individual traits.

The conclusions we can draw about the Artificial Grammar Learning Paradigm (AGL) as the sole potential measure of implicit learning are relatively limited. However, the AGL did not correlate with intelligence (consistent with Sobkow et al., 2018), openness (contrary to Sobkow et al., 2018), or other measures in the experimental battery—except for semantic coherence intuition in the RAT, prior to applying Bonferroni correction.

4.4.3 The Role of Individual Differences

With respect to the question of whether there are individual differences in the capacity for intuition, our findings demonstrate that individuals with higher cognitive abilities and openness to experience are more likely to perform well on tasks that require the detection of coherence or spontaneous insight into the solution of a problem. This ability to correctly deduce meaning from fragmentary cues may be enhanced by higher crystallized intelligence, as it is associated with a larger set of information stored in memory and greater proficiency in recalling and utilizing this information (cf. Cattell, 1963). On the other hand, fluid intelligence reflects the ability to solve novel and abstract problems (cf. Cattell, 1963; Horn & Cattell, 1966) and may play a role in effectively integrating this information. Openness, in turn, potentially enhances performance in these tasks, by enabling individuals to approach problems with a flexible and exploratory mindset, considering diverse viewpoints and possibilities.

Given that intelligence and openness also predict individual differences in creativity (e.g., Feist, 1998; Karwowski et al., 2016; Kaufman et al., 2016; McCrae, 1987; Silvia, 2008), and intuition has been theorized as a crucial component in creative processes (e.g., Dane & Pratt, 2009; Pétervári et al., 2016), one primary factor distinguishing measures of coherence and insight from the remaining instruments could be their reliance on flexibility and originality in thinking. This is consistent with the fact that the RAT was originally proposed as a measure of creativity (Mednick, 1962).

Contrary, our results demonstrate that other types of intuitive processes are not influenced by individual characteristics, supporting the notion that these are truly implicit performances with little individual variation in functioning (cf. Reber et al., 1991). More generally, although intelligence and openness do contribute to coherence detection and insight, overall few personality traits appear to have consistent predictive value for intuitive processes. In this regard, previous research has associated neuroticism with heuristics and biases in decision-making (Denburg et al., 2009; Hilbig, 2008); however, our results indicate that neuroticism does not influence any of the evaluated measures.

Similarly, although conscientiousness is a well-established predictor of task performance (e.g., Debusscher et al., 2017; Gellatly, 1996; Meyer et al., 2009), we found no correlation between conscientiousness and any measure of intuitive performance. However, conscientiousness was correlated with both the sensing dimension of the MBTI ($r = .24$; which interestingly contradicts recent findings by Furnham, 2022) and, before correcting for multiple testing, with the FI dimension of the REI ($r = .18$; which replicates Alós-Ferrer et al., 2016; Epstein et al., 1996; Pacini & Epstein, 1999; Witteman et al., 2009). This suggests that conscientiousness may influence metacognitive feelings about one's own intuitive ability, but less so the actual ability to intuit.

4.4.4 The Range of Intuitive Processes in Dual-System Theories

"One of the stronger bases for dual-systems theory is the evidence that 'controlled' cognitive processing correlates with individual differences in general intelligence and working memory capacity, whereas 'automatic' processing does not." (Evans, 2008, p. 262). Along these lines, some dual-processing accounts of human cognition have proposed that automatic processes are independent of explicit cognitive resources (e.g., Evans, 2008; Reber, 1993; Stanovich, 1999). In contrast, our findings provide evidence that performance in certain instruments, which are widely considered to capture automatic processes, is in fact augmented by cognitive ability.

While we acknowledge that these tasks involve intentional and cognitively controlled components, there are further components that cannot be assumed to operate at this level. This is supported by our finding that coherence judgments in the RAT are often made without explicit insight into the solution word. Similarly, participants in the ACT tend to underestimate their progress toward the solution, suggesting the presence of implicit components that are not consciously accessible (Bowers et al., 1990; Reber et al., 2007).

Reflecting these discrepancies and other theoretical debates surrounding dual-process models, Evans (2008, p. 255) concludes that:

> *(a)* there are multiple kinds of implicit processes described by different theorists and *(b)* not all of the proposed attributes of the two kinds of processing can be sensibly mapped on to two systems as currently conceived. It is suggested that while some dual-process theories are concerned with parallel competing processes involving explicit and implicit knowledge systems, others are concerned with the influence of preconscious processes that contextualize and shape deliberative reasoning and decision-making.

In this regard, our experiment offers robust evidence in support of this theoretical differentiation, as measures of coherence intuition and insight appear to capture a dynamic interplay between explicit and implicit processes, which may also explain why performance in these tasks is predicted by individual characteristics. In contrast, other measures, such as Anchoring Paradigms or Paradigms of Artificial Grammar Learning, may rather assess exclusively implicit processes that spontaneously acquire patterns of information and provide context to deliberate reasoning. Interestingly, however, while Artificial Grammar Learning Paradigms provide evidence on the efficiency of these underlying mechanisms, Anchoring Paradigms serve as a striking demonstration of how some of these basic processes can lead to bias. Similarly, the CRT appears to capture a distinct mechanism by assessing participants' ability to override the biased outcomes of the very process (see Evans, 2008; for a discussion of *default-interventionist* models).

4.4.5 Conclusion

In conclusion, intuition is a diversely operationalized construct, and the measures assessed in the current experiment capture a range of processes, not all of which appear to be exclusively implicit. In this regard, measures of coherence and insight might capture a dynamic interplay between explicit and implicit knowledge systems, which could clarify their observed link to openness and cognitive ability. In contrast, other measures could assess a range of implicit pre-processing mechanisms that acquire patterns of information and provide context to deliberate reasoning (cf. Evans, 2008). Thus, as Evans (2008) has noted, “although dual-process theories enjoy good empirical support …, the superficially attractive notion that they are all related to the same underlying two systems of cognition is probably mistaken” (p. 271).

Against this background, researchers should clearly delineate the specific type of intuition they are investigating, as generalizations often mask important differences (cf. Glöckner & Witteman, 2010). Moreover, questionnaires assessing intuitive processing tendencies do not positively align with performance measures, raising concerns about their suitability as proxies.

CHAPTER 5: GENERAL DISCUSSION

Most human thinking and reasoning is a mixture of conscious and unconscious components (Baars & Gage, 2010). In this respect, intuitive processes are an inherent aspect of human cognition. Nevertheless, despite a certain consensus on their phenomenological experience as a sense of knowing, perspectives on what intuition is, how it works, and how it can be studied have been remarkably diverse. The phenomenon has been variously interpreted, including notions of intuition as a sophisticated knowledge process (e.g., Bowers et al., 1990; Dijksterhuis & Nordgren, 2006; Klein, 1993), a "fast and frugal" decision algorithm (e.g., Gigerenzer & Goldstein, 1996; Gigerenzer & Todd, 1999), or even as simple bias-prone heuristic (e.g., Frederick, 2002; Kahneman & Frederick, 2002; Tversky & Kahneman, 1973).

Considering the potential heterogeneity of implicit processes that have been labeled as "intuitive", the current dissertation aimed to provide a meta-perspective on the field. Thus, rather than attempting to reconcile different accounts on intuition, I focused on mapping the diverse perspectives on this phenomenon (Chapter 2) and evaluated psychometric methods derived from them (Chapters 3 and 4).

In conclusion, intuition is a diversely defined and operationalized construct, with existing measures capturing a variety of cognitive phenomena that are, for the most part, unrelated. Further, contrary to the widely held view that intuitive-automatic processes are independent of explicit cognitive resources (e.g., Evans, 2008; Reber, 1993; Stanovich, 1999), the present findings suggest that certain processes are, in fact, augmented by cognitive ability (see Chapter 4). Thus, while some intuitive mechanisms may pre-process patterns of information and provide context to deliberate reasoning, others not only seem to involve both implicit and explicit resources (cf. Evans, 2008) but may even contribute to intelligent behavior (Kaufman, 2011; Sobkow et al., 2018).

This once again highlights the multifaceted nature of intuitive functions, suggesting that intuition is far from being a unified phenomenon. Instead, it appears to be a collection of diverse cognitive mechanisms that share certain superficial characteristics, such as their automaticity, the sense of knowing they evoke, and their resistance to articulation. Thus, while the subjective experience of intuition appears to be relatively uniform, the underlying processes that generate these feelings of knowing may vary significantly. As a result, studying intuition remains a complex endeavor, as different mechanisms may contribute to similar subjective experiences. In this respect, there are several factors inherent to the phenomenon that make its study a particularly challenging area of inquiry.

5.1 The Problems with Intuition

5.1.1 Intuitive Judgements can be Accurate or Flawed – the Feeling is the Same

Perhaps the most problematic aspect of intuition is that its mechanisms occur mostly unconsciously, rendering them non-transparent to the individual experiencing them. Thus, while individuals are typically aware of the feeling these mechanisms evoke (i.e., the hunch, the gut feeling, the sense of knowing), they are usually not sensible to where that feeling comes from (Betsch, 2008; Glöckner & Witteman, 2010; Hogarth, 2001).

As Kahneman and Klein (2009) note: "The judgments and decisions that we are most likely to call intuitive come to mind on their own, without explicit awareness of the evoking cues and of course without an explicit evaluation of the validity of these cues." (p. 519). In other words, because the underlying processes occur unconsciously, their reliability—and thus, the accuracy of the ensuing judgments—can hardly be verified.

On the one hand, a chess master may truly *feel* the best move, without explicitly analyzing all potential outcomes (Simon & Chase, 1973). Similarly, a professional firefighter may rely on their intuition to accurately assess the risk and initiate an evacuation of the area

(Klein, 1993; Klein et al., 2010). However, on the other hand, a stock market trader may rely on his gut feeling but face significant losses due to the unpredictable nature of the stock market (Kahneman & Klein, 2009).

Thus, intuitive hunches can be based on considerable implicit knowledge, but they can also be based on distorted information or the improper application of decision heuristics (Hogarth, 2010; Kahneman & Klein, 2009). They can be based on a single cue (e.g., Gigerenzer & Goldstein, 1999) or the synthesis of various cues (e.g., Betsch & Glöckner, 2010; Hammond et al., 1964), likewise, on cues that are highly predictive (e.g., Gigerenzer & Goldstein, 2011) or on those of questionable validity (e.g., Frederick, 2005; Jacowitz & Kahneman, 1995)—the feeling of certainty appears to be the same. Thus, while the subjective experience of intuition is apparently quite uniform, it can arise from diverse cognitive mechanisms, ranging from advanced knowledge processes to simple heuristic strategies.

5.1.2 Intuitive Processes are not Directly Observable

This not only makes it difficult for individuals to determine when to trust their intuitive hunches, it also presents a significant challenge for researchers. Specifically, because the processes underlying intuitive feelings take place without conscious awareness, they cannot be described by individuals, nor can they be directly observed.

Thus, while researchers can typically observe the outcomes of intuitive processes—such as the judgement itself, the feeling of knowing, and the potential biases that arise—they cannot directly observe the mental processes that produce these outcomes (cf. Hogarth, 2010). In response, a wide range of methods have been developed to capture intuitive processes indirectly, such as inferring these processes through solution speed (e.g., Bowers et al., 1990; Löffler & Topolinski, 2023), judgment accuracy (e.g., Bowers et al., 1990; Frederick, 2005;

Reber, 1967; Tversky & Kahneman, 1974), confidence ratings (e.g., Koriat et al., 2008; Simmons & Nelson, 2006), or response behavior (e.g., Gigerenzer & Goldstein, 1996; Glöckner & Betsch, 2008; Hammond et al., 1987).

Nevertheless, there always remains a degree of uncertainty regarding the relationship between these measures and the cognitive processes involved. Thus, as Hogarth (2010) has rightly pointed out, “investigators typically have to take ‘leaps of faith’ concerning models of underlying processes.” (p. 338).

5.1.3 Different Assumptions lead to Different Conclusions

Correspondingly, the absence of directly observable evidence for intuitive processes has likely contributed to the fragmentation of the field. In particular, researchers appear to have reached drastically different conclusions based on their underlying assumptions about the mind.

For Kahneman and his collaborators, intuitive processes are a more primitive addition to conscious ones, operating on rather basic heuristic principles (e.g., Kahneman & Frederick, 2002; Morewedge & Kahneman, 2010; Tversky and Kahneman, 1974). In contrast, Gigerenzer argues that, despite certain limitations, heuristic processes efficiently exploit the structure of the environment (e.g., Gigerenzer & Brighton, 2009; Gigerenzer and Gaissmaier, 2011; Gigerenzer & Todd, 1999). Other authors propose that unconscious processes can integrate information from various sources in a holistic manner (e.g., Betsch and Glöckner, 2010; Bowers et al., 1990; Klein, 1993). Some even posit that unconscious processes might be superior in addressing complex problems compared to conscious ones (e.g., Dijksterhuis, 2004; Dijksterhuis and Nordgren, 2006).

Given these diverse perspectives, there appears to be disagreement on a number of fundamental questions. One such question concerns whether there are capacity constraints in human information processing, and if so, to what extent such constraints might limit human decision-making. In this regard, both Kahneman and Gigerenzer have drawn on Simon's (1955) idea of *bounded rationality*, arguing that people use resource-efficient decision strategies. However, in the tradition of Meehl's (1954) work, Kahneman and colleagues emphasize the fallibility of these strategies (e.g., Kahneman & Frederick, 2002; Tversky & Kahneman, 1974). In contrast, Gigerenzer and colleagues, drawing on an evolutionary perspective, highlight their adaptive value and ecological rationality (e.g., Gigerenzer, 1991; Gigerenzer & Todd, 1999).

While Kahneman and Gigerenzer both offer interpretations of bounded rationality, other researchers, including Hammond et al. (1964), Reber (1967), Bowers (1990), and Dijksterhuis (2004), have drawn on Gestalt psychological principles. Rather than assuming constraints in human information processing, they have emphasized the capacity of unconscious processes to holistically combine various sources of information into coherent decisions. However, while all emphasize the ability of intuitive processes to synthesize complex information, they diverge in their conceptualizations of the cognitive mechanisms at play (see Chapter 2). Ultimately, this illustrates the challenge of developing a comprehensive framework for intuition, as different foundational beliefs inevitably seem to result in different conclusions about the mind.

5.1.4 Different Methods lead to Different Conclusions

In light of this, different measurement methods not only shape how intuitive processes are interpreted but also determine which cognitive mechanisms are observed (see Chapter 4). In this respect, the nature and functions of intuitive processes appear to vary significantly depending on the specific unconscious mechanism involved (for a related discussion, see Bargh & Morsella, 2008).

For instance, as discussed in Chapter 4, the intuitive acquisition of artificial grammar seems largely independent of cognitive ability, whereas the mechanisms underlying semantic coherence perception seem to be complemented by it. This divergence suggests that while certain intuitive processes may require minimal explicit engagement (cf. Evans, 2008), others integrate both implicit and explicit resources (see Chapter 4).

More broadly, this indicates that human cognition encompasses a wide range of different mechanisms supporting essential processes such as perception, language, learning, and habituation of behavior in distinct ways (cf. Evans, 2008). Thus, although dual-process theories have traditionally drawn a clear dichotomy between conscious and unconscious cognition, categorizing all implicit functions under the umbrella term "intuition" risks conflating fundamentally different phenomena (Glöckner & Witteman, 2010).

In this regard, conclusions about intuition have rarely been mechanism-specific, as theoretical frameworks typically focus on the distinction between conscious and unconscious cognition, rather than addressing the diversity of unconscious mechanisms. This raises the concern that the term "intuitive" may have frequently been used to act as a mere placeholder for cognitive functions that remain insufficiently explained. Thus, rather than fostering a deeper understanding of them, it might simply mask gaps in our theories (cf. Topolinski, 2017).

5.2 Implications

In summary, intuition is a complex phenomenon, and several inherent factors make its study a particularly challenging area of inquiry. Thus, while we can speculate about the mechanisms involved and evaluate our hypotheses using indirect approaches, the fact remains that many aspects of intuition remain difficult to quantify. Ultimately, we cannot simply look into people's minds—and neither can they. This leaves researchers with the challenging task of bridging significant theoretical gaps between observable behaviors and the cognitive processes underlying them (cf. Hogarth, 2010).

Against this background, it may have been useful to adopt a broad and inclusive definition of intuitive phenomena (cf. Hodgkinson et al., 2008). As such, the term "intuition" has served as a broad categorization for implicit phenomena that are associated with a particular metacognitive experience. However, given the diverse mental functions that seem to contribute to the formation of intuitive feelings, there is a risk of conflating fundamentally different functions under the same label (Glöckner & Witteman, 2010). Thus, while an inclusive approach may facilitate intra-disciplinary discussions, it seems essential to consider the diversity of cognitive mechanisms underlying intuitive feelings rather than drawing generalized conclusions from them.

In this regard, "intuition" has served as a loosely defined umbrella term for processes that share superficial characteristics but often defy more precise classification (cf. Glöckner & Witteman, 2010; Topolinski, 2017). This lack of conceptual clarity, however, ultimately hinders fruitful discussions, as it obscures important distinctions between mechanisms and leads to theoretical ambiguity. Thus, despite substantial evidence for a wide range of intuitive-automatic processes, our understanding of the mind remains fragmented without a framework to meaningfully distinguish among them.

In this respect, it is crucial to establish a more refined taxonomy that takes into account the different types and functional roles of intuitive processes. A promising step in this direction has already been made, as several authors have proposed models that differentiate among various types of intuitive processes (e.g., Dane & Pratt, 2009; Glöckner & Witteman, 2010; Gore & Sadler-Smith, 2011; Hogarth, 2001; see Chapter 2). Nevertheless, there is still a need for empirical work that compares different intuitive mechanisms and explores their connections with other aspects of psychological functioning (see Chapter 4; Sobkow et al., 2018). Thus, to gain a more comprehensive understanding, researchers need to adopt a broader perspective and take into consideration various related phenomena—such as learning, memory, affect, and creativity (Hogarth, 2010; see also Hodgkinson et al., 2008).

Moreover, considering the growing evidence for the heterogeneity of intuitive functions, it seems that overly simplistic frameworks—such as the monolithic division into deliberate and automatic—have created additional barriers to categorizing these diverse phenomena. In this respect, dual-process models have traditionally emphasized the contrast between intuitive and deliberate processes by outlining their general characteristics. Paradoxically, this seems to have led to considerable disagreement about what constitutes the *true* nature of intuition (cf. Glöckner & Witteman, 2010). Thus, although dual-process theories have undoubtedly provided useful frameworks for illustrating different forms of cognition, it has become increasingly clear that there are various kinds of intuitive-automatic processes and thus no single, definitive type of intuition.

That is, not only does current research reveal a more diverse spectrum of intuitive phenomena than once assumed, it also suggests that many of these processes cannot be neatly categorized within a simple dichotomy (cf. Evans, 2008). For this reason, it seems imperative to critically reassess some of the foundational assumptions that have shaped our views on human cognition. In this regard, it is probably more useful to assume that many processes are a joint function of automatic and reflective processing, rather than falling neatly into one or the other category (see Chapter 4; see also Evans, 2008; Glöckner & Witteman, 2010; Hammond et al., 1987).

5.3 Conclusion

Unconscious mental functions have fascinated researchers since the beginning of modern psychology. Correspondingly, the study of intuition has long been a major area of research, attracting considerable attention over the years. However, despite—or perhaps because of—the abundance of research in this area, the conceptualization of intuition has remained rather vague.

Some authors have conceptualized intuitive processes as a rudimentary addition to conscious ones, operating according to simple heuristic principles (e.g., Kahneman & Frederick, 2002; Morewedge & Kahneman, 2010; Tversky & Kahneman, 1974). Some have argued that intuitive processes, although based on simple strategies, are highly effective in exploiting the structure of complex environments (e.g., Gigerenzer & Brighton, 2009; Gigerenzer and Gaissmaier, 2011; Gigerenzer & Todd, 1999). Other authors have proposed that intuitive processes are capable of synthesizing various sources of information in a holistic, parallel manner (e.g., Betsch & Glöckner, 2010; Deutsch & Strack, 2008). Some have even argued that unconscious processes may outperform conscious ones when it comes to solving complex problems (e.g., Dijksterhuis, 2004; Dijksterhuis & Nordgren, 2006).

In summary, a variety of different, sometimes even conflicting, perspectives on intuitive-automatic functions and their capacities have been proposed. This conceptual ambiguity appears to be partly due to different foundational beliefs, but also because many aspects of intuition remain ultimately difficult to quantify. The variability of intuitive functions further complicates the issue, as different intuitive mechanisms appear to operate under different cognitive constraints (for a related discussion, see Bargh & Morsella, 2008).

As a result, the term "intuition" has served as a broad, loosely defined label rather than a concept with precise theoretical boundaries (cf. Glöckner & Witteman, 2010). Thus, intuition is not a singular phenomenon, but rather a collection of diverse cognitive processes that share superficial characteristics but often differ in their mechanisms and functions.

In this respect, there are various kinds of intuitive-automatic processes and thus no single, definitive type of intuition. Therefore, conclusions about intuition must be mechanism-specific, as the diversity of unconscious processes prevents broader generalization. This highlights the need for a more nuanced perspective on intuitive-automatic processes, that takes into account their diverse mechanisms and functional roles. Not only does current research reveal a more diverse spectrum of intuitive phenomena than previously assumed, but it also suggests that many of these processes cannot be categorized into a simple deliberate-intuitive dichotomy (cf. Evans, 2008; see also Glöckner & Witteman, 2010; Hammond et al., 1987; Hogarth, 2010).

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APPENDIX

Appendix A: Accumulated Clues Task (Chapter 3)

Word lists of the ACT, each denominated after their solution word (English translation in parentheses), with the clues' mean semantic proximity to the solution word (pre-study)

List 1:	**FABRIK (FACTORY)**	
	Clues	$M_{\text{Proximity}}$
Clue 1	SCHLOT	4.12
Clue 2	BACKSTEIN	4.21
Clue 3	KONZERN	6.02
Clue 4	GELÄNDE	6.39
Clue 5	SCHICHT	6.64
Clue 6	HERSTELLER	6.73
Clue 7	BETRIEB	7.11
Clue 8	MECHANISCH	7.31
Clue 9	FERTIGUNG	7.49
Clue 10	HALLE	7.85
Clue 11	MASCHINE	8.05
Clue 12	FLIEßBAND	8.16
Clue 13	ARBEITER	8.18
Clue 14	PRODUKTION	8.36
Clue 15	INDUSTRIE	8.79
List 2:	**BACH (STREAM)**	
	Clues	$M_{\text{Proximity}}$
Clue 1	SCHMAL	3.81
Clue 2	BRÜCKE	5.02
Clue 3	UFER	5.08
Clue 4	MÜNDEN	5.26
Clue 5	QUELLE	5.72
Clue 6	LAUF	5.73
Clue 7	PLÄTSCHERN	5.84
Clue 8	SCHILF	5.95
Clue 9	BAROCK	6.61

Clue 10	GEWÄSSER	6.96
Clue 11	DAMM	7.37
Clue 12	ORGEL	7.55
Clue 13	KOMPONIST	8.32
Clue 14	MÜHLE	8.61
Clue 15	FLUSS	8.65
List 3:	**BOOT (BOAT)**	
	Clues	$M_{\text{Proximity}}$
Clue 1	SCHAUKELN	4.81
Clue 2	KURS	5.20
Clue 3	SCHLAUCH	6.10
Clue 4	WRACK	6.24
Clue 5	KENTERN	6.33
Clue 6	BUG	6.35
Clue 7	MOTOR	6.40
Clue 8	MARINE	6.53
Clue 9	SCHWIMMEN	6.54
Clue 10	ANKER	7.01
Clue 11	RUDER	7.29
Clue 12	FISCHER	7.30
Clue 13	SEGEL	7.57
Clue 14	MEER	8.00
Clue 15	SCHIFF	8.78
List 4:	**MARMOR (MARBLE)**	
	Clues	$M_{\text{Proximity}}$
Clue 1	ERLESEN	3.61
Clue 2	ADER	3.96
Clue 3	KALK	4.19
Clue 4	MASERUNG	5.20
Clue 5	GRAB	5.29
Clue 6	BÜSTE	5.37
Clue 7	MEIßEL	5.42
Clue 8	SÄULE	6.47
Clue 9	WEIß	6.63

Clue 10	PLATTE	6.80
Clue 11	GLATT	6.99
Clue 12	KUCHEN	7.09
Clue 13	HART	7.58
Clue 14	STATUE	7.74
Clue 15	STEIN	8.99
List 5:	**ZUG (TRAIN)**	
	Clues	$M_{\text{Proximity}}$
Clue 1	VOGEL	2.17
Clue 2	LINIE	4.63
Clue 3	FAHRZEUG	4.68
Clue 4	RESERVIEREN	5.19
Clue 5	GÜTER	5.83
Clue 6	KLASSE	5.96
Clue 7	ANBINDUNG	6.00
Clue 8	REISE	6.40
Clue 9	PASSAGIER	6.70
Clue 10	ABTEIL	7.64
Clue 11	SITZPLATZ	7.70
Clue 12	LOK	8.25
Clue 13	SCHAFFNER	8.74
Clue 14	WAGGON	9.13
Clue 15	BAHNHOF	9.27
List 6:	**MUND (MOUTH)**	
	Clues	$M_{\text{Proximity}}$
Clue 1	BEFEUCHTEN	4.80
Clue 2	TROCKEN	4.88
Clue 3	BART	5.20
Clue 4	KOPF	5.32
Clue 5	VOLL	5.72
Clue 6	ATMUNG	5.94
Clue 7	ÖFFNUNG	6.21
Clue 8	MIMIK	6.53
Clue 9	SCHLUCKEN	7.25

Clue 10	KIEFER	7.57
Clue 11	KAUEN	7.81
Clue 12	ZÄHNE	8.48
Clue 13	SPRECHEN	8.58
Clue 14	ESSEN	8.78
Clue 15	LIPPEN	8.98
List 7:	**LAMM (LAMB)**	
	Clues	***M*Proximity**
Clue 1	SCHMOREN	3.37
Clue 2	KIND	3.57
Clue 3	FRÜHLING	3.64
Clue 4	ZART	4.67
Clue 5	KEULE	4.90
Clue 6	UNSCHULD	5.78
Clue 7	WEIß	5.82
Clue 8	OSTERN	5.82
Clue 9	FELL	6.00
Clue 10	KOTELETT	6.35
Clue 11	JUNG	6.43
Clue 12	WEIDE	6.72
Clue 13	WOLLE	6.97
Clue 14	HIRTE	7.33
Clue 15	SCHAF	8.40
List 8:	**SILBER (SILVER)**	
	Clues	***M*Proximity**
Clue 1	ANLAUFEN	4.22
Clue 2	SPIEGEL	4.32
Clue 3	FISCH	5.30
Clue 4	SCHIMMERN	5.36
Clue 5	ERZ	5.73
Clue 6	LEGIERUNG	6.01
Clue 7	GLANZ	6.38
Clue 8	MINE	6.64
Clue 9	MÜNZE	6.85

Clue 10	SCHMIED	7.21
Clue 11	GOLD	7.71
Clue 12	MEDAILLE	7.76
Clue 13	EDEL	7.91
Clue 14	SCHMUCK	8.23
Clue 15	METALL	8.42
List 9:	**ADLER (EAGLE)**	
	Clues	***M*Proximity**
Clue 1	STEIN	3.05
Clue 2	WIPFEL	3.12
Clue 3	SEE	4.03
Clue 4	WIND	4.16
Clue 5	SCHWINGEN	5.18
Clue 6	SYMPBOL	5.31
Clue 7	KREISEN	5.49
Clue 8	SPANNWEITE	6.01
Clue 9	HORST	6.09
Clue 10	WAPPEN	6.40
Clue 11	KRALLEN	7.00
Clue 12	AUGE	7.51
Clue 13	SCHNABEL	7.87
Clue 14	FEDER	8.45
Clue 15	GREIFVOGEL	9.01
List 10:	**TREPPE (STAIRCASE)**	
	Clues	***M*Proximity**
Clue 1	PODEST	3.53
Clue 2	HALLE	3.54
Clue 3	KNARREN	3.83
Clue 4	BETRETEN	4.43
Clue 5	LEITER	4.83
Clue 6	STEIL	4.96
Clue 7	KELLER	5.67
Clue 8	FAHRSTUHL	5.83
Clue 9	WENDEL	6.38

Clue 10	AUFGANG	6.55
Clue 11	ABSATZ	6.85
Clue 12	HINUNTER	6.92
Clue 13	STOCKWERK	7.40
Clue 14	GELÄNDER	7.80
Clue 15	STUFE	9.15
List 11:	**GLAS (GLASS)**	
	Clues	$M_{\text{Proximity}}$
Clue 1	KNOCHEN	3.83
Clue 2	SCHLEIFEN	4.71
Clue 3	SPRUNG	5.15
Clue 4	QUARZ	5.34
Clue 5	HAUS	5.38
Clue 6	GLANZ	5.47
Clue 7	SAND	5.64
Clue 8	SPLITTERN	6.26
Clue 9	KRISTALL	6.39
Clue 10	SPIEGEL	6.89
Clue 11	BRILLE	7.43
Clue 12	TRANSPARENT	7.82
Clue 13	SCHERBE	8.23
Clue 14	FENSTER	8.49
Clue 15	SCHEIBE	8.63
List 12:	**DRAHT (WIRE)**	
	Clues	$M_{\text{Proximity}}$
Clue 1	DURCHBRENNEN	3.12
Clue 2	SCHLINGE	3.94
Clue 3	ESEL	3.99
Clue 4	WICKELN	4.09
Clue 5	GLÜHEN	4.41
Clue 6	STACHEL	5.35
Clue 7	BÜRSTE	5.84
Clue 8	LÖTEN	6.15
Clue 9	ELEKTRIZITÄT	6.18

Clue 10	MASCHEN	6.27
Clue 11	KUPFER	6.43
Clue 12	BIEGSAM	6.57
Clue 13	LEITUNG	6.92
Clue 14	ZAUN	6.96
Clue 15	METALL	7.39
List 13:	**NACHT (NIGHT)**	
	Clues	***M*Proximity**
Clue 1	FEUER	3.08
Clue 2	MORGEN	4.55
Clue 3	NEBEL	4.65
Clue 4	LAGER	4.71
Clue 5	WACHE	4.82
Clue 6	DIENST	5.27
Clue 7	KÜHL	5.78
Clue 8	TAG	6.12
Clue 9	EULE	6.85
Clue 10	DÄMMERUNG	6.97
Clue 11	RUHE	7.42
Clue 12	BETT	7.89
Clue 13	STERN	8.21
Clue 14	SCHLAF	8.91
Clue 15	DUNKELHEIT	9.52
List 14:	**SCHACHTEL (BOX)**	
	Clues	***M*Proximity**
Clue 1	KASSETTE	2.99
Clue 2	HOLZ	3.24
Clue 3	SCHUH	4.28
Clue 4	GESCHENK	4.92
Clue 5	INHALT	5.19
Clue 6	SCHATULLE	5.72
Clue 7	ÖFFNEN	6.03
Clue 8	AUFBEWAHREN	6.15
Clue 9	BEHÄLTER	6.29

Clue 10	ZIGARETTE	6.47
Clue 11	KARTON	6.88
Clue 12	PRALINEN	6.99
Clue 13	STREICHHOLZ	7.51
Clue 14	VERPACKUNG	7.63
Clue 15	BOX	7.96
List 15:	**KUPPEL (DOME)**	
	Clues	***M*Proximity**
Clue 1	ÜBERSPANNEN	3.68
Clue 2	DURCHMESSER	4.74
Clue 3	BOGEN	4.81
Clue 4	MOSCHEE	5.35
Clue 5	GEWÖLBE	6.02
Clue 6	GEBÄUDE	6.07
Clue 7	HOCH	6.29
Clue 8	DECKE	6.30
Clue 9	KATHEDRALE	6.31
Clue 10	ARCHITEKTUR	6.62
Clue 11	WÖLBEN	6.64
Clue 12	PLANETARIUM	6.77
Clue 13	RUND	7.72
Clue 14	HALBKUGEL	7.76
Clue 15	DOM	7.87
List 16:	**MANTEL (COAT)**	
	Clues	***M*Proximity**
Clue 1	KABEL	2.94
Clue 2	ROCK	3.03
Clue 3	REIFEN	3.31
Clue 4	HÜLLE	3.77
Clue 5	UNIFORM	3.95
Clue 6	FUTTER	5.08
Clue 7	KNOPF	5.16
Clue 8	PELZ	5.71
Clue 9	WOLLE	5.88

Clue 10	KRAGEN	6.16
Clue 11	JACKE	7.25
Clue 12	MODE	7.38
Clue 13	LANG	7.56
Clue 14	KLEIDUNG	8.13
Clue 15	WINTER	8.76

List 17:	**SALBE (OINTMENT)**	
	Clues	***M*Proximity**
Clue 1	HEXE	2.81
Clue 2	TALG	3.42
Clue 3	TINKTUR	4.90
Clue 4	JUCKEN	5.72
Clue 5	REIBEN	6.10
Clue 6	VERBRENNUNG	6.30
Clue 7	FETT	6.77
Clue 8	WIRKSTOFF	6.85
Clue 9	LINDERN	7.25
Clue 10	ARZNEI	7.43
Clue 11	HAUT	7.84
Clue 12	HEILEN	7.98
Clue 13	APOTHEKE	8.18
Clue 14	AUFTRAGEN	8.60
Clue 15	CREME	8.81

List 18:	**PUNKT (POINT/DOT)**	
	Clues	***M*Proximity**
Clue 1	WUND	2.12
Clue 2	THEMA	2.92
Clue 3	FLECK	3.24
Clue 4	ORT	3.61
Clue 5	PLATZIERUNG	3.76
Clue 6	ZIEL	4.00
Clue 7	ZEIT	4.24
Clue 8	LINIE	4.40
Clue 9	STRICH	5.21

Clue 10	LANDUNG	5.71
Clue 11	STOPP	5.88
Clue 12	GENAU	5.93
Clue 13	ZEICHEN	7.80
Clue 14	ENDE	7.99
Clue 15	KOMMA	8.75
List 19:	**KNOTEN (KNOT)**	
	Clues	***M*Proximity**
Clue 1	ZUNGE	3.35
Clue 2	BRUST	3.45
Clue 3	ACHT	4.12
Clue 4	VERSCHLUNGEN	4.22
Clue 5	GESCHWINDIGKEIT	4.75
Clue 6	HAAR	4.82
Clue 7	DOPPELT	5.21
Clue 8	MATROSE	5.26
Clue 9	ZUSAMMENZIEHEN	5.48
Clue 10	KRAWATTE	5.60
Clue 11	FEST	5.70
Clue 12	SCHLEIFE	6.34
Clue 13	SCHLAUFE	7.28
Clue 14	BINDEN	7.47
Clue 15	SEIL	8.18
List 20:	**PAAR (PAIR)**	
	Clues	***M*Proximity**
Clue 1	STORCH	2.33
Clue 2	ALLEIN	2.53
Clue 3	HOSE	3.44
Clue 4	LAUF	3.98
Clue 5	KIND	4.46
Clue 6	HUF	4.66
Clue 7	TRENNUNG	5.08
Clue 8	BRAUT	5.42
Clue 9	ZWILLING	6.00

Clue 10	ZUEINANDER	6.15
Clue 11	TANZ	6.18
Clue 12	EHE	7.35
Clue 13	ZUSAMMENGEHÖRIG	7.72
Clue 14	SOCKEN	7.91
Clue 15	PARTNER	8.15

Appendix B: Supplementary Materials (Chapter 4)

Self-Assessed Performance

As detailed in the method section, each performance measure in the experimental battery was followed by participants' self-assessment of their own performance in that task. A scale from 0 (*0% accurate*) to 10 (*100% accurate*) was applied. Our preregistration included an additional hypothesis concerning the moderating role of personality traits between participants' self-assessed and objective intuitive performance. To keep the scope of our project within reasonable limits, testing of this hypothesis was omitted from the paper but is reported below.

Linear Mixed-Effect Models

To explore the potential influence of openness and neuroticism on the relationship between self-assessed and objective intuitive performance, we ran a separate linear mixed-effect model for each performance measure of intuitive processing, respectively. Prior to analysis, self-assessed and objective performance scores were each converted into z-scores and all variables were mean centered. Each model included objective performance as criterion and self-assessed performance, openness, and neuroticism as fixed effects. Additionally, we included interaction terms between self-assessed performance and openness/neuroticism to examine potential moderating effects.

Regarding performance in the CRT, our analysis revealed significant main effects of both self-assessed performance, $\beta = 0.63$, $t = 11.32$, $p < .01$, 95% CIdifference = [0.52, 0.74], and openness, $\beta = 0.18$, $t = 2.62$, $p < .01$, 95% CIdifference = [0.05, 0.32]. However, there was no main effect of neuroticism and no interaction effect (all *ps* > .234).

For performance in the Anchoring Paradigm, we found a significant main effect of self-assessed performance, $\beta = 0.28$, $t = 4.21$, $p < .01$, 95% CIdifference = [0.15, 0.41], whereas the main effects of openness and neuroticism as well as the interaction terms were non-significant (all *ps* > .435).

Regarding performance in the RAT, a significant main effect of openness was revealed, $\beta = 0.22$, $t = 2.44$, $p = .015$, 95% CIdifference = [0.04, 0.39]. The main effects of self-assessed performance, neuroticism, and both interaction terms were non-significant (all *ps* > .161).

For performance in the ACT, we found significant main effects of both self-assessed performance, $\beta = 0.16$, $t = 2.36$, $p = .019$, 95% CIdifference = [0.03, 0.29], and openness, $\beta = 0.25$, $t = 2.91$, $p < .01$, 95% CIdifference = [0.08, 0.42]. Again, there was no main effect of neuroticism, and neither of the interaction terms were significant (all *ps* > .143).

Regarding performance in the GCT, we found a significant main effect of openness, $\beta = 0.17$, $t = 1.98$, $p = .049$, 95% CIdifference = [0.00, 0.35]. However, there were no main effects of self-assessed performance or neuroticism, and no interaction effects (all *ps* > .148).

Our analysis of performance in the AGL did not reveal any significant main effects or interactions in the calculated model (all *ps* > .073).

In summary, these findings suggest that neither openness nor neuroticism moderate the association between self-assessed and objective intuitive performance, which we deem as support for the null hypothesis.