The Wiley Blackwell Handbook of Judgment and Decision Making

Volume I

Edited by **Gideon Keren and George Wu**

WILEY Blackwell

This edition first published
2015 © 2015 John Wiley
& Sons, Ltd

Registered Office

John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex,

P019 8SQ, UK *Editorial Offices*
350 Main Street, Malden, MA 02148-5020, USA ^
9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, P019 8SQ, UK

For details of our global editorial offices, for customer services, and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell.

Library of Congress Cataloging-in-Publication Data

The Wiley Blackwell handbook of judgment and decision making / edited by Gideon Keren, George Wu. volumes cm Includes bibliographical references and index.
ISBN 978-1-118-46839-5 (hardback)
1. Decision making. 2. Judgment. I. Keren, Gideon. II. Wu, George.
BF448.W55 2015 153.4'6-dc23
2015002776

A catalogue record for this book is available from the British Library.

Set in 10/12.5pt Galliard by SPi Global,
Pondicherry, India Printed and bound in Malaysia
by Vivar

Metacognition: Decision making Processes in Self-monitoring and Self-regulation

Asher Koriat

Department of Psychology, University of Haifa, Israel

Introduction

Metacognition is generally defined as knowing about knowing or thinking about thinking. This definition implies a distinction between two levels of cognitive operations, as captured by the conceptual framework proposed by Nelson and Narens (1990). They distinguished between object-level and meta level processes. The object-level processes include basic information-processing operations that are engaged in encoding, learning, and remembering. The meta level, in turn, includes higher-order processes that oversee object-level processes and regulate their operation towards the achievement of various goals. The distinction, of course, is not sharp; many processes that are involved in judgment and decision making possibly engage both types of processes. However, this distinction has been found quite useful.

Meta level processes are assumed to include two general functions - monitoring and control (Nelson & Narens, 1990). The monitoring function includes the reflective processes involved in observing and supervising cognitive processes online, and in evaluating their fluency, their progress, and their success. For example a student preparing for an exam must make an online assessment of his comprehension of the material and decide whether he is prepared for the exam or needs to continue studying. The control function refers to the top-down strategic management and regulation of cognitive processes according to various considerations. Researchers in metacognition generally assume that the output from the meta-cognitive monitoring serves to inform metacognitive control (e.g., Nelson & Narens, 1990). For example, in preparing for an exam, students must choose what learning strategy to use, how much time to allocate to different parts of the materials, which parts of the materials to restudy, and when to end study. Such

The Wiley Blackwell Handbook of Judgment and Decision Making, First Edition. Edited by Gideon Keren and George Wu.

metacognitive control operations are normally guided by the online feedback from monitoring operations but must also take into account the students' goals (Ariel, Dunlosky, & Bailey, 2009) as well as their metacognitive beliefs about learning and memory in general and about their own skills in particular.

It is clear from the foregoing discussion that there is a great deal of overlap between the processes investigated in the context of metacognition and those studied by students of judgment and decision making. The distinctive feature of metacognition research is the concern with processes that take one's own cognitive operations as their object. Underlying much of the work on metacognition is a view of the person as an organism who monitors and actively regulates his cognitive processes toward the achievement of various goals. Such a view is dominant in social psychology and in decision making but has played a less prominent role in traditional information-processing models. Metacognitive researchers share the assumption that self-controlled processes should be treated as an integral part of memory functioning Goldsmith & Koriat, 2008). Furthermore, optimal cognitive performance is assumed m depend critically on the effectiveness of self-monitoring and self-regulation (Bjork, Dunlosky, & Kornell, 2013). The focus on self-monitoring implies that subjective beliefs and subjective feelings play a causal role in the dynamics of cognitive processes and behavior, rather than being mere epiphenomena (Koriat, 2000). The emphasis on self-regulation, in turn, departs from the traditional methodological approach in the study of learning and remembering, in which an attempt has been made to minimize the role of self-directed processes on performance (see Koriat & Goldsmith, 1996). For example, items have been presented for study at a fixed rate rather than allowing learners to self-pace their study. Also, in recognition memory testing, a forced-choice format has typically been used rather than allowing participants the option to decide which answers to volunteer and which to withhold (as is standardly the case for witnesses in court).

Because of the interest in subjective feelings and self-regulation, the study of metacognition has been attracting the attention of philosophers who are concerned with issues of agency, consciousness, and subjective experience (Carruthers, 2011; Proust, 2013). In addition, the topic of metacognition has been pulling under one umbrella researchers and theoreticians from various disciplines, including learning rand memory, developmental psychology, perception, judgment and decision making, animal cognition, and neuroscience (see Beran, Brandl, Perner, & Proust, 2012).

Central questions in metacognition

In this chapter I will focus narrowly on experimental work on the metacognitive processes that occur during learning and remembering. This work is more tightly linked to issues discussed in the context of judgment and decision making.

The experimental work in metacognition has concentrated on five core issues (see Koriat, 2007). The first concerns the bases of metacognitive judgments: for example, what is the basis of the feeling-of-knowing that people sometimes experience when they fail to retrieve a name? The second issue concerns the accuracy of metacognitive figments - the correspondence between subjective and objective indices of knowing mid the factors that affect that correspondence (e.g., Dunning, Heath, & Suls, 2004). The third issue concerns the processes underlying the accuracy and inaccuracy of metacognitive judgments (Koriat, 1995). In particular, what are the processes that lead to illusions of knowing and to dissociations between knowing and the feeling of knowing (e.g., Benjamin & Bjork, 1996; Koriat, 1995)? The fourth concerns the strategic regulation of learning and remembering. In particular, how does the output monitoring affect control processes (e.g., Son & Metcalfe, 2000)? Finally, how do the metacognitive processes of monitoring and control affect actual memory performing (e.g., Koriat & Goldsmith, 1996; Metcalfe & Kornell, 2003)?

Metacognitive monitoring: types of judgments

A variety of judgments have been studied in recent years that are relevant to metacognition. Among these are ease-of-learning judgments (Leonesio & Nelson, 1990), judgments of comprehension (R. H. Maki & McGuire, 2002), remember/know judgments (Gardiner & Richardson-Klavehn, 2000), output- monitoring (Koriat, Ben-Zur, & Sheffer, 1988), metaperceptual evaluations (Loussouarn, Gabriel, & Proust, 2011), source monitoring (Johnson, 1997), and the monitoring of one’s own forgetting (Halamish, McGillivray, & Castel, 2011).

However, the bulk of the experimental work has concerned three types of judgments. First are judgments of learning (JOLs) elicited following the study of each item. For example, after studying each paired-associate in a list, participants are asked to assess the likelihood that they will be able to recall the target word in response to the cue word in a future test. These judgments are then compared to the actual recall performance. Second are feeling-of-knowing (FOK) judgments that are elicited following blocked recall. When participants fail to retrieve a name or a term from memory they are asked to make FOK judgments regarding the likelihood that they will be able to select the correct answer from among several distractors in a future forced-choice test. The validity of FOK judgments is then evaluated against performance in a subsequent recognition memory test. Finally, after retrieving an answer from or after solving a problem the subjective confidence in the correctness of that answer is elicited, sometimes in the form of a probability judgment reflecting the assessed likelihood that the answer is correct. Whereas JOLs and FOK judgments are prospective, involving predictions of future memory performance, confidence judgments are retrospective, involving assessments about a response that has been produced. Many different variations of these general paradigms have been explored, including variations in the type of memory studied (semantic, episodic, autobiographical, eyewitness-type events, etc.), the format of the memory test (free recall, cued recall, forced-choice recognition, etc.), and the particular judgments elicited (item-by-item judgments or global judgments, using a probability or a rating scale, etc.).

The bases of metacognitive judgments

A central question in metacognition concerns the bases of metacognitive judgments. The assumption is that understanding the cognitive basis of metacognitive judgments should provide a key to understanding the accuracies and inaccuracies of these judgments.

Three general approaches to the bases of metacognitive judgments have been considered: the *direct-access approach*, the *information-based approach*, and the *experience-based approach* (see Koriat, 2007). The direct-access view is perhaps best represented in the philosophy of knowledge by the claims of rationalist philosophers that a priori truths (e.g., mathematical propositions) are based on intuition and deduction land that their certainty is self-evident. In memory research, the direct-access (or trace-access) approach assumes, that metacognitive judgments reflect privileged access to the [presence and strength of stored memory traces (see Dunlosky & Metcalfe, 2009). For example, it was proposed that JOLs are based on detecting the strength of the memory trace that is formed following learning (e.g., Cohen, Sandler, & Keglevich, 1991). Similarly, FOK judgments were said to monitor the actual presence of the elusive target in the memory store (Hart, 1965). In the case of confidence judgments, too, a direct-access view generally underlies the use of such judgments in the context of strength theories of memory (see Van Zandt, 2000).

In contrast to the direct-access view, a cue-utilization view has been gaining popularity in metacognition research (see Koriat, 1997). According to this view, metacognitive judgments are inferential in nature, relying on a variety of beliefs and heuristics. A distinction is drawn, however, between information-based and experience-based judgments (Kelley & Jacoby, 1996; Koriat, Nussinson, Bless, & Shaked, 2008). Information-based judgments rely on an analytic inference in which various considerations are consulted to reach an educated judgment. For example, it has been claimed that JOLs rely on the person’s theories about how various characteristics of the [study material, or the conditions of learning, influence memory performance (Koriat, 1997). Similarly, FOK judgments have been said to rest on deliberate inferences from one’s own beliefs and knowledge (Costermans, Lories, & Ansay, 1992). Discussions of subjective confidence also emphasize information-driven processes: confidence in two-alternative forced-choice (2AFC) general-knowledge questions was claimed to rest on the reasons recruited in favor of the two answers (e.g., Griffin & Tversky, 1992; Koriat, Lichtenstein, & Fischhoff, 1980).

Experience-based judgments, in contrast, are based on sheer subjective feelings. Indeed, there has been a growing emphasis in memory research and in social-psychological research on the role of subjective feelings in guiding judgments and behavior (Kelley & Jacoby, 1996; Schwarz & Clore, 2007). Metacognitive feelings are assumed to stem primarily from the fluency of processing (see Alter & Oppenheimer, 2009; Unkelbach & Greifeneder, 2013b). Thus, results suggest that JOLs made during study rest on the ease with which to-be-remembered items are encoded or retrieved during learning (Karpicke, 2009; Koriat & Ma'ayan, 2005; Koriat, Ma'ayan, & Nussinson, 2006). It has been claimed of FOK judgments that they rely on the familiarity of the pointer that serves to probe memory (Reder, 1988; Schwartz & Metcalfe, 1992) or on the accessibility of partial clues during the search for the memory target (Koriat, 1993,1995). Confidence judgments, too, are said to rest on fluency of selecting or retrieving an answer (e.g., Kelley & Lindsay, 1993; Koriat, Ma'ayan et al., 2006; Robinson, Johnson, & Herndon, 1997).

The distinction between information-based and experience-based metacognitive judgments overlaps with distinctions made in the context of dual-process theories (see Chaiken & Trope, 1999; Kahneman, 2003; Kelley & Jacoby, 1996; Koriat, Bjork, Sheffer, & Bar, 2004). Three features have been emphasized in distinguishing between them (Koriat et al., 2008). First, information-based judgments draw on the declarative content of domain-specific beliefs that are retrieved from long-term memory whereas experience-based judgments rely on all-purpose mnemonic cues (such as encoding or retrieval fluency) that are devoid of declarative content. This distinction is nicely illustrated by the extensive work of Schwarz and his associates using the ease of retrieval paradigm (see Schwarz, 2015, for a review). For example, Schwarz et al. (1991) asked participants to recall either six or 12 examples of assertive behaviors. Self-ratings of assertiveness were *higher* after recalling six rather than 12 examples suggesting that participants based their self-ratings on the subjective experience of ease or difficulty of recall rather than on the recalled content. These and other results indicate that the effects of ease of retrieval can override the effects of the declarative content of the retrieved information. Second, in the case of information-based judgments, the inferential process is an explicit, deliberate process that yields an educated, reasoned assessment. In experience-based judgments, in contrast, the process that gives rise to a subjective feeling is implicit and largely unconscious. Jacoby ant his associates proposed that subjective experience, in general, is shaped by a process which fluent processing is attributed unconsciously to a particular source (e.g.. Jacoby & Dallas, 1981). Finally, the process underlying information-based judgments is a dedicated process that is initiated and compiled ad hoc with the goal of producing judgments. Experience-based judgments, in contrast, are based on the very experience of learning, remembering, and deciding: they are parasitic on normal, object-level cognitive operations.

Let us examine now some of the theories and research on metacognitive process during learning and remembering. It will be shown that some general principles transpire across discussions of different types of metacognitive processes.

Metacognitive Processes During Learning

In a typical experiment on JOLs participants are presented with a list of paired-associates that they are required to study for a future cued-recall test. Following the study of each pair they make JOLs reflecting the likelihood that they would be able to recall the second word at test in response to the cue word. Sometimes participants are also required to provide an aggregate judgment at the end of the study block reflecting the number of items that they are likely to recall. Whereas many studies used a fixed-time presentation others used a self-paced procedure in which participants are allowed to control the amount of time that they allocate to the study of each item.

What is the basis of JOLs? As noted, some researchers implied a trace-access view. For example, it has been proposed that in self-paced learning learners detecting increase in encoding strength that occurs as more time is spent studying each item (Cohen et al., 1991) and cease study when a preset "norm of study" has been reached (Dunlosky & Hertzog, 1998). In contrast to this view, most authors subscribe to tire cue-utilization view of JOLs (e.g., Benjamin & Bjork, 1996; Koriat, 1997), according to which JOLs are inferential: learners rely on a variety of cues in making recall predictions. Although there is indication that JOLs may be based on beliefs about the factors that are likely to affect recall (Mueller, Tauber, & Dunlosky, 2013) many findings suggest that JOLs are influenced by experiential cues, such as encoding fluency and retrieval fluency, which derive from task performance. In fact, studies indicate that participants hardly apply their declarative knowledge and theories in making JOLs. For example, Koriat et al. (2004) found that JOLs made during learning are entirely indifferent to the expected retention interval, although actual recall exhibits a typical forgetting function. Thus, participants studying a list of paired-associates gave similar JOLs whether they expected to be tested immediately after study, after a week, or even after a year. One condition that yielded sensitivity to retention interval is "forgetting framing" - when learners predicted forgetting ("how many words will you forget") rather than remembering ("how many words will you recall"). This result suggests that participants apply their theory about forgetting only when the notion of forgetting is activated. Kornell and Bjork (2009) also found that JOLs fail to take into account the effects of the expected number of study trials on memory. The implication of these studies is that learners do not spontaneously apply some of the most basic beliefs about learning and remembering in making JOLs but rely primarily on the "here and now" - on mnemonic cues (such as ease of processing) that derive consequentially from task performance (See Bjork et al., 2013; Koriat et al., 2008).

Other studies also demonstrated marked dissociations between JOLs and memory performance. Benjamin, Bjork, and Schwartz (1998) had participants answer several questions and then assess the likelihood that they would be able to recall the answer in a final free-recall test. The more rapidly participants retrieved an answer to a question the higher was their estimate that they would be able to recall that answer at a later time. In reality, however, the opposite was the case. Also, Rhodes and Castel (2008) had participants study words that varied in font size. Although JOLs were influenced by the font size of the words, font size was completely non diagnostic of future recall.

Another dissociation was demonstrated by Koriat and Bjork (2005). They proposed that learners often experience overconfidence in their mastery of the studied materials because some of the information present during study (e.g., the answer to potential questions) will be unavailable but solicited during testing. The failure to discount the effects of that information was assumed to result in a *foresight bias*, which is similar to the extensively studied hindsight bias (Fischhoff, 1975). However, unlike the hindsight bias, which occurs when the recall of one's past answer is made in the presence of the correct answer, the foresight bias occurs when predictions about one's success in recalling the correct answer are made in the presence of that answer. Using paired-associates learning, a series of studies indicated that JOLs are inflated when the to-be-recalled target highlights aspects of the cue that are not transparent when the cue appears alone (at test) (Koriat & Bjork, 2006a, 2006b).

An interesting extension of the notion of foresight bias is the *prediction inflation* phenomenon (Koriat, Fiedler, & Bjork, 2006; W. S. Maki, 2007). When participants make conditional predictions - assessing the probability that a certain outcome will occur given a certain conditions their predictions tend to be markedly inflated (some- times predicting .60 when the actual probability is .02). This inflation also appears to derive from a backward activation in which the target outcome highlights aspects of the condition that are consistent with that outcome, thus supporting the plausibility of that outcome. One consequence of this process is that alternative outcomes are not conceived, to compete as fully as they should (see Teigen, 1983).

By and large, however, JOLs tend to be quite accurate in predicting recall performance. The accuracy of JOL has been examined using procedures similar to those applied to confidence judgments by researchers in the area of judgment and decision making (Lichtenstein, Fischhoff, & Phillips, 1982). Two aspects of metacognitive accuracy have been distinguished: calibration and resolution. Cafibration or bias, refers roughly to the correspondence between mean metacognitive judgments and mean actual memory performance, and it reflects the extent to which metacognitive judgments are realistic or exhibit underconfidence or overconfidence. Calibration or bias, can also be assessed by eliciting global or aggregate predictions (Koriat, Sheffer, & Ma'ayan, 2002), for example, by asking participants to estimate how many items they will be able to recall. Several studies suggest that, by and large, item-by-item JOLs are well calibrated on the first study-test trial. However, JOLs exhibit two trends that replicate those observed for retrospective confidence. First, aggregate judgments, when transformed into percentages, are substantially lower than item-by-item judgments. Whereas the latter judgments tend to be relatively well calibrates aggregate judgments tend to yield underconfidence (Koriat et al., 2002, 2004); thus is similar to the trend reported for confidence judgments (Griffin & Tversky, 1992). Second, the calibration curve for JOLs for the first presentation of a study list (Koriat et al., 2002) exhibits the typical pattern observed for retrospective confidence (see Erev, Wallsten, & Budcscu, 1994) - an underconfidence bias when JOL is low and an overconfidence bias when JOL is high.

In addition, when learners are presented with the same list of items for several study-test cycles their JOLs exhibit relatively good calibration on the first cycle, with a tendency toward overconfidence. However, a shift toward marked underconfidence occurs from the second cycle on. This underconfidence-with-practice (UWP) effect was found to be very robust across several experimental manipulations (Koirat et al., 2002).

Turning next to resolution, the within-person correlation between JOLs and subsequent memory performance is moderate for a list of paired associates that includes both related and unrelated pairs (Koriat et al., 2002). Monitoring seems to be particularly poor when it concerns one's own actions. When participants perform a series of minitasks and judge the likelihood of recalling these tasks in the future the accuracy of their predictions is quite poor. Possibly people have special difficulties in monitoring their own actions (e.g., Koriat, Ben-Zur, & Druch, 1991).

As in many discussions in the area of judgment and decision making (Gigerenzer, Hoffrage, & Kleinbolting, 1991), Brunswik's lens model (Brunswik, 1956) has proved useful for the analysis of JOL resolution (see Koriat, Ma'ayan et al., 2006). Assuming that JOLs are based on mnemonic cues such as encoding fluency or retrieval fluency, the correlation between JOL and a given mnemonic cue can be used as an index of *cue utilization*; the correlation between the mnemonic cue and recall, as an« index of *cue validity,* and the JOL-recall correlation, as an index of *achievement.* The results are generally consistent with the assumption that the accuracy of JOL ("achievement") is mediated by the extent to which JOLs rely on specific mnemonic cues and by the predictive validity of these cues.

Two procedures proved effective in improving JOL accuracy. The first involves presenting the same list for several study-test blocks. Although repeated practice studying the same list of items impairs calibration, as noted earlier, it does improve resolution substantially (Koriat et al., 2002). Evidence reported by Koriat (1997) and Koriat, Ma'ayan, and Nussinson (2006) suggests that the improvement in resolution with practice occurs because, with increased practice studying a list of items, learners increasingly rely on idiosyncratic mnemonic cues deriving from study experience (cue utilization). In parallel, the accuracy of these cues in predicting recall also increases cue validity). The result is improved JOL resolution with practice.

The second procedure is delaying JOLs: the accuracy of JOLs in predicting subsequent memory performance in paired-associates learning is substantially higher when JOLs are solicited sometime after study than when they are solicited immediately after study (Nelson & Dunlosky, 1991). The results of Koriat and Ma'ayan (2005) suggest that this is because with the delay in soliciting JOLs a shift occurs in [the basis of JOLs from reliance on encoding fluency (the ease with which an item is committed to memory) toward greater reliance on retrieval fluency (the ease with which the target comes to mind in response to the cue). In parallel, the validity of retrieval fluency in predicting recall increases with delay and becomes much higher Khan that of encoding fluency. These results suggest that metacognitive judgments may be based on the flexible and adaptive utilization of different mnemonic cues according to their relative validity in predicting memory performance.

Both of the procedures just mentioned - repeated practice and delaying JOLs – have been found to help in alleviating the foresight bias that instills an illusion of competence during study (Koriat & Bjork, 2006a, 2006b). These procedures seem to sensitize learners during learning to mnemonic cues that are relevant to retrieval conditions at test.

Let us turn next to examination of the metacognitive regulation of learning. A review of the literature concludes that learners do not tend to know about how best reassess and manage their own learning (Bjork et al., 2013). They are not aware of power of spacing and fail to incorporate spacing into their study routines. They also fail to appreciate that tests produce more learning than does similar time spent studying without being tested and do not make sufficient use of self-testing as a strategy to enhance learning (Karpicke, 2009).

Several studies have focused specifically on the relationship between metacognitive monitoring and metacognitive control. Underlying that work is the "monitoring-affects-control" hypothesis (Nelson & Leonesio, 1988). One finding that has been taken to support this hypothesis is that in self-paced learning participants spend more time studying judged-difficult items than judged-easy items (see Son & Metcalfe, 2000 for a review). According to the *discrepancy-reduction model* (Dunlosky & Hertzog, 1998), study-time allocation is guided by the attempt to reduce the discrepancy between actual and desired knowledge state. Therefore, learners allocate more study time to the judged-difficult items in order to compensate for their difficulty.

Inconsistent with this interpretation, Koriat, Ma'ayan et al., (2006) observed that the allocation of more study time to difficult than to easy items failed to reduce the effects of items difficulty either on recall or on JOLs. They proposed that study time, like other metacognitive operations, actually plays a control function as well as a monitoring function. The control function is captured by the Monitoring —> Control] (MC) model, according to which the allocation of study time is based on JOLs and is used in the service of specific goals. The goal-driven function of the allocation of study time is clearly demonstrated by the effects of incentive: when the incentive associated with recall is manipulated differentially between items in a list learners allocate more study time to high-incentive than to low-incentive items (Ariel et al., 2009; Dunlosky & Thiede, 1998), and JOLs increase accordingly with increased study time (Koriat, Ma'ayan et al., 2006). Thus, JOLs increase with increased study time.

The monitoring function of study time, in contrast, becomes clear when the basis of JOLs is examined. Koriat, Ma'ayan, and Nussinson (2006) proposed that it is by attempting to commit an item to memory that learners judge whether they would be likely to recall it in the future. They argued that in self-paced learning, study time allocation is generally data-driven rather than goal-driven: it is determined ad hoc by the item itself. Thus, learners spend as much time and effort as the item calls for, and their JOL is then based retrospectively on the memorizing effort heuristic according to which the more effort needed to study an item the *lower* its likelihood to be recalled at test. Thus, study time is used by the learner as an index of encoding fluency (see Undorf & Erdfeider, 2013). The data-driven view of study time implies a Control ➔ Monitoring (CM) model in which the output from metacognitive control serves to inform metacognitive monitoring.

The MC and CM models were expected to yield diametrically opposed relationships between JOL and study time: JOLs were expected to increase with study time when study time is goal-driven but to decrease with study time when study time is data-driven. Koriat, Ma'ayan, and Nussinson (2006) found both types of relations within the same situation, suggesting that the two models are not mutually exclusive. In one experiment (Experiment 5), participants were awarded different incentives to the successful recall of different items, one point versus three points. This manipulation produced a positive relationship between JOLs and study time: participants invested more study time in the three-point items and in parallel assigned *higher* JOLs, to these items than to the one-point items. At the same time, however, a negative relationship between JOLs and study time was observed within each incentive leyeB so that the more study time was invested in an item, the *lower* was the JOL associated with that item. Importantly, the pattern of results obtained for metacognitive monitoring tends to mirror actual memory performance (Koriat, Ackerman, Adiv, Lockl, & Schneider, 2013). Exactly the same pattern was observed for confidence judgments! (discussed in the section Retrospective Confidence in One's Answers and Judgments).

The occurrence of a positive and a negative study-time-JOL relationship within the same situation implies an attribution process in which participants attribute differences in study time in different proportions to data-driven and goal-driven regulation before making their JOL. The reality of this attribution was brought to the fore by Koriat and Nussinson (2009). They asked learners to adopt a facial expression that creates a feeling of effort, and induced them to ascribe that effort either to data-driven or to goal-driven regulation. The facial expression of effort was found to decrease JOLs when it was imputed to data-driven regulation but to enhance JOLs when it was attributed to goal-driven regulation. This and other results are consistent with the view that participants can be induced to adopt opposite theories about the implications of processing fluency, and these theories can modulate experience-based metacognitive judgments (Schwarz, 2015; Unkelbach, 2006).

It should be stressed that the dimension of data-driven effort corresponds to the dimension of fluent versus disfluent processing, which has received a great deal of research in recent years (see Schwarz, 2015; Unkelbach & Greifeneder, 2013b). Fluency--disfluency refers to the amount of effort *required* by the task in a bottom-up fashion. However, effort can also be allocated by the person willfully in a top-down, goal-driven fashion. Goal-driven effort has played an important role in studies of attention and performance (e.g., Kahneman, 1973) and in attribution theories of motivation (e.g., Weiner, 1985). So far, however, theories of fluency have concerned primarily data-driven effort (e.g., Unkelbach & Greifeneder, 2013a). However, they should also incorporate the notion of goal-driven effort, particularly because the two types of effort seem to have diametrically opposite effects on metacognitive judgments.

The contrast between the MC and CM models is reminiscent of the issue raised by William James (1884): Do we run away because we are frightened, or are we frightened because we run away? The MC model accords with the view that subjective feelings (e.g., fear) drive behavior (e.g., running away). James's own position - that feelings are based on the feedback from one's own bodily reactions (see Strack & Deutsch, 2004) - is more consistent with the CM model. The work reviewed above suggests that the two models are not mutually exclusive. Evidence suggests that they can occur within the same situation (Koriat, Ma'ayan et al., 2006; Koriat et al., 2013), but they can also occur sequentially, so that control ➔ monitoring ➔ control (Koriat & Ackerman, 2010).

Going back to the question of how study time is allocated, two other models have been proposed. First is the *region of proximal learning model* (Metcalfe, 2002; Metcalfe & Kornell, 2003). This model assumes that learners do not necessarily allocate more study time to the more difficult items. Rather, learners' effort is most effective in what is referred to as *region of proximal learning* - a state in which the items are neither fully learned nor completely unlearned. According to this model, learners use their metacognitive monitoring to try to isolate their own region of proximal learning and to study selectively within it (Metcalfe, 2002).

Another model, *agenda-based regulation* (ABR), assumes that learners develop an agenda in which they try to allocate study time in an optimal manner that minimizes study time and maximizes goal achievement. They do so also in selecting items for restudy. Results in support of this model were reported by Ariel et al. (2009). For example, they found that although learners generally invest more study time in difficult items, they tend to choose the easier items for restudy when they are given an easy goal (e.g., to get only a few items correct; Dunlosky & Thiede, 2004; Thiede & Dunlosky, 1999). Learners also invest more time in the items that are more likely to be tested. These observations suggest the operation of an adaptive goal-oriented agenda.

If metacognitive monitoring glides control operations then monitoring accuracy should play a critical role for effective performance (Koriat & Goldsmith, 1996). Indeed, for the monitoring of one's own learning, manipulations that enhance monitoring accuracy were found to improve the effectiveness of study-time allocation between different items as well as overall recall performance (Thiede, Anderson, & Therriault, 2003).

Metacognitive Processes During Remembering

A basic property of the memory system is the limited access to the information stored in long-term memory. Because the retrieval of a specific memory target is generally effortful, it is advantageous for a rememberer to know whether the sought-for target is indeed available in memory and is worth searching for. Indeed, studies indicate that when rememberers fail to recall a word they can judge with some accuracy whether, they would be able to recall or recognize that word in the future. In his pioneering research, Hart (1965) devised a simple paradigm for investigating FOK accuracy. Participants are presented with a series of general-information questions and are asked to recall the answer (usually a name or a term). When they fail to recall the correct answer, they are asked to make a FOK judgment: predict whether they will be able to choose the correct answer on a multiple-choice test. Accuracy in FOK is assessed by comparing FOK judgments with recognition success. The results obtained with this paradigm indicate that participants can judge whether they will be able to recognize the elusive target among distractors.

Related to the FOK state is the tip-of-the-tongue (TOT) state. In their pioneering study, R. Brown and McNeill (1966) observed that when participants reported that they are in a TOT state they could report correctly partial phonological information about the elusive word or name, such as the first letter, and the number of syllables. Since that work, it has been shown that participants can also provide semantic partial information pertaining to semantic and associative aspects of the target (Koriat, Levy- Sadot, Edry, & de Marcas, 2003).

The FOK phenomenon has attracted attention because it instantiates a dissociation between objective and subjective indices of knowing: the person is unable to recall a particular word or name but is nevertheless quite confident that the word or name is; available in memory and will be recalled or recognized in the future. Sometimes the subjective experience is so intense that one feels that the elusive item is on the verge of emerging into consciousness (see A. S. Brown, 2012). Naturally, the question arises, How do people know that they know?

As with JOLs solicited during study, the most straightforward explanation is that FOK is based on privileged access to the underlying memory trace. Hart (1965) proposed that FOK judgments are based on accessing a special monitoring mechanism that can directly inspect the information stored in memory and can detect the availability of information that is momentarily inaccessible. Such a monitoring mechanism can spare the effort of searching for a memory target that is not in store. The important feature of the trace-access model is that it also explains why FOK is a valid predictor of actual memory performance.

The trace-access approach has focused attention on the accuracy of FOK and ha$ impeded investigation of its possible bases. As noted earlier, the more recent approaches assume that FOK judgments are inferential in nature. Although FOK judgments can be based on beliefs and retrieved memories (e.g., “I have read the book, so I *should* know the name of the author”) they are often based on experiential cues. Three heuristic-based accounts have been proposed to underlie experience-based FOK judgments. According to the cue familiarity hypothesis, FOK is based on the familiarity of the pointer that serves to probe memory (Metcalfe, Schwartz, & Joaquim, 1993; Reder, 1988). Indeed, the advance priming of the terms of a question (assumed to enhance the familiarity of the question) was found to enhance FOK judgments without correspondingly raising the probability of recall or recognition of the answer (Reder, 1988; Schwartz & Metcalfe, 1992).

According to the accessibility account, in contrast, FOK is based on the overall accessibility of pertinent information regarding the solicited target (Koriat, 1993). Even when retrieval fails, people may still retrieve a variety of partial clues and activations, and these clues can induce the subjective feeling that the target is stored in memory. An important assumption of the accessibility account is that correct clues and incorrect clues contribute equally to FOK judgments. Indeed, in Koriat’s study (1993), FOK regarding the future recallability of a studied letter string increased with the number of letters that participants reported regardless of the accuracy of these letters. In addition, FOK increased with the ease with which information came to mind, as reflected in the latency to initiate recall.

If FOK judgments increase with the accessibility of both correct and incorrect partial information, why are they nevertheless accurate in predicting *correct* recall or recognition of the target? Koriat (1993) argued that the accuracy of FOK derives from the accuracy of memory itself: when recall of a memory target fails, the partial information that comes to mind is much more likely to be correct than wrong. Therefore, the total amount of partial information accessible is a good cue for recalling or recognizing the *correct* target. Thus, the accuracy of FOK judgments may be accounted for in terms of the accuracy of memory itself with no need to postulate privileged access to memory traces as a basis of FOK.

The advantage of mnemonic-based accounts of FOK is that they can also explain illusory FOK judgments. Consistent with the cue-familiarity account, enhanced familiarity of the pointer was found to result in unwarranted high FOK judgments (Reder, 1988; Schwartz & Metcalfe, 1992). Also, Schwartz (1998) reported that some questions may even produce an illusory TOT experience. For example, when presented with the question "What is the last name of the Canadian author who wrote the novel *The Last Bucket**" a considerable proportion of participants reported a TOT state even though the question has actually no real answer.

A similar dissociation, consistent with the accessibility account, was reported by Koriat (1995) using different types of general-information questions. Unlike typical questions, which tend to bring to mind more correct than incorrect partial information, deceptive questions, like those used by Fischhoff, Slovic, and Lichtenstein (1977) in their study of confidence judgments (e.g., "What is the capital of Australia?"), tend to produce predominantly incorrect partial information. For such questions, FOK judgments made following recall failure were found to be *negatively* correlated with subsequent recognition memory performance (Koriat, 1995).

A third account of FOK judgments is a two-stage model that combines: dje] cue-familiarity and accessibility accounts (Koriat & Levy-Sadot, 2001). Results suggest that familiarity, in addition to affecting FOK judgments directly, also serves as gating mechanism for the effects of accessibility: when familiarity is high, participants probe their memory for the answer, and then the amount of information accessible more likely to affect FOK. When familiarity is low, the effects of potential accessibility on FOK are more limited.

Discussions of the function of FOK have stressed the effects of FOK in driving memory search. It was proposed that when people feel that they know the answer to a question, they try harder to look for it (Schwartz, 2001). This proposition is consistent with the monitoring-drives-control (MC) model. Indeed, Reder (1988) has specifically argued that preliminary FOK judgments guide the selection of strategies that people use to answer questions or solve problems.

However, the accessibility account of FOK actually implies that monitoring is based on the feedback from control operations. The assumption is that it is by searching for a memory target that participants “know” whether an unrecallable item is available in memory. As with JOLs, however, the MC and CM models need not be mutually exclusive: FOK may be based on the feedback from the search for a memory target and may then motivate further search for the target.

Retrospective Confidence in One’s Answers and Judgments

Confidence judgments in one’s own knowledge and judgments have been investigated in a wide range of domains including perception and psychophysics, judgment and decision making, memory and metacognition, and eyewitness testimony. Increased interest in confidence judgments can also be seen in such areas as social cognition animal cognition, and neuroscience (see Dunlosky & Metcalfe, 2009). The study of subjective confidence represents perhaps the strongest overlap between research in the area of judgment and decision making and research on metacognition. My discussion and review of that work will be very selective, focusing on ideas and studies that were inspired by some of the dominant views in metacognition.

The two lines of research on subjective confidence seem to differ somewhat in their emphases. The work in metacognition by memory researchers has focused much more on resolution than on calibration. The observation that people can tell when they know and when they do not know, when they are right and when they are wrong has been among the steering forces for the upsurge of interest in metacognition. Somewhat strangely, this observation has received relatively little attention among students of judgment and decision making. As noted by Keren (1991), virtually calibration curves reported in the experimental literature are monotonically increasing suggesting good resolution. Similarly, in studies of recognition memory, it has been noted that low-confidence decisions are associated with close-to-chance accuracy whereas high-confidence decisions tend to be associated with close-to-perfect accuracy (Mickes, Hwe, Wais, & Wixted, 2011). However, the extensive research on "assessed probabilities," spurred by the work of Lichtenstein et al. (1982), has focused on patterns of miscalibration (e.g., Griffin & Brenner, 2004), taking for granted the accuracy of monitoring resolution. In fact, within the judgment and decision tradition there seems to be an implicit assumption that assessed probabilities ought to be perfectly calibrated, and hence the challenge is to explain deviations from perfect calibration. In metacognition research, in contrast, one of the research goals has been to uncover the bases of confidence judgments and to explain why these judgments are accurate by and large.

A related difference seems to reflect a difference in research agendas. In the area of judgment and decision making, proponents of the ecological probability approach (Dhami, Hertwig, & Hoffrage, 2004; Gigerenzer et al., 1991) argued that some of pie biases documented with regard to assessed probabilities (e.g., the overconfidence bias, Hoffrage, 2004; the hard-easy effect, Griffin & Tversky, 1992) derive from the failure of researchers to sample items that are representative of the natural environment. This criticism has generated research that focused on the *empirical* question whether the biases observed are "real," and indeed several results suggest that confidence judgments are well calibrated for representative items (Gigerenzer et al., 1991; Juslin, 1993, 1994). In metacognition research, in contrast, researchers have sometimes deliberately used conditions that are ecologically unrepresentative, even conntrived (Benjamin et al., 1,998; Brewer & Sampaio, 2006; Koriat, 1995, 2008a), in order to demonstrate dissociations between metacognitive judgments and memory performance. The difference between the two lines of research seems to reflect a difference between two sometimes conflicting research agendas (see Koriat, Pansky, & goldsmith, 2011). The first is to obtain a faithful description of the state of affairs in the real world, and the second is to achieve a theoretical understanding of the phenomena and their underlying mechanisms. Whereas the former agenda calls for a proper representation of items, conditions, and subject populations that reflect the ecology toward which generalizations are intended, the latter sometimes calls precisely for the use of a biased representation of items and conditions that helps untangle rambles that go hand in hand in real life (Koriat, 2012a).

What is the basis of subjective confidence? In strength theories of memory, the dominant view of the basis of confidence judgments is very close to that of the trace-press approach. Confidence is assumed to be scaled from the strength or quality of the internal memory representation (see Van Zandt, 2000). Metacognition researchers, in contrast have focused on the effects of various manipulations that lead confidence judgments astray. Interestingly, all the manipulations act in one direction: inflating confidence judgments (see Roediger, Wixted, & DeSoto, 2012). Several studies indicated that confidence is enhanced by manipulations that increase fluency of processing. In a study by Chandler (1994), participants were presented with a series of target and nontarget pictures. Targets for which there existed a similar stimulus in the nontarget series were recognized less often but were endorsed with stronger confidence than gargets for which no similar nontarget counterpart was included. In other studies, post-event questioning, in which participants were asked to think about each of their responses in a memory test, increased subsequent confidence ratings for these responses (Shaw, 1996), presumably because questioning increased retrieval fluency. Studies of the illusory- truth effect indicated that the mere familiarity and fluency of a statement which are caused by its repetition or by its context, can influence the perceived truth of that statement (Hasher, Goldstein, & Toppino, 1977). In line with the ease-of-retrieval effect of Schwarz and his associates (see Schwarz, 2015), when participants were asked to list four reasons in support of their answer their confidence in the answer was lower than when they were asked to list only one supporting reason (Koriat et al., 2008).

Other research suggests that confidence judgments are based specifically on retrieval latency. Nelson and Narens (1990) found that people express stronger confidence in the answers that they retrieve more quickly, whether those answers, are correct or incorrect. Similarly, Kelley and Lindsay (1993) had participants answer general-information questions. Prior to this task, participants were asked to read a series of words some of the words were correct and some of them were plausible but incorrect answers to the questions. This prior exposure was found to increase the speed and probability with which the answers were provided in the recall test, and in parallel, to enhance confidence in the correctness of these answers. This was true for both correct and incorrect answers. These results support the view that retrospective confidence is based on a simple heuristic: answers that come to mind easily are more likely to be correct than those that take longer to retrieve (Robinson et al., 1997).

Results suggest that confidence is also influenced by the mere amount of information that an item brings to mind (Koriat, 2008b, 2012a). Merely increasing the amount of knowledge available was found to enhance confidence in judgments (Gill, Swann, & Silvera, 1998), sometimes even while decreasing accuracy (Hall, Ariss, & Todorov, 2007).

A recent model of subjective confidence - the Self-Consistency Model (SCM; Koriat, 2012a) - focused on explaining the positive within-person confidence/accuracy (C/A) correlation that has been observed in innumerable studies. Results suggested that this correlation is an artifactual consequence of the fact that in all of these studies participants were more likely to be correct than wrong (Koriat, 2008a, 2011). That is, when participants choose an answer to a 2AFC item, the correct answer is typically the consensual answer - the one chosen by most participants. When confidence and consensuality are dissociated, however, confidence is found to correlate with the consensuality of the answer, not with its correctness. Thus, studies that included a sufficiently large number of items for which most participants chose the wrong answer yielded a positive C/A correlation only for consensually correct (CG) items, for which most participants chose the correct answer. For consensually wrong (CW) items, in contrast, the C/A correlation was consistently *negative*: people were more confident when they were wrong than when they were right. This pattern was observed for a word-matching task (Koriat, 1976), general - knowledge (Koriat, 2008a), semantic memory (Brewer & Sampaio, 2012), perceptual judgments (Koriat, 2011), episodic memory (Brewer & Sampaio, 2006) and the predictions of others' responses (Koriat, 2012a). Choice latency exhibited a similar pattern: whereas CG items yielded the typical pattern of accuracy decreasing with choice latency, CW items yielded the reverse relationship.

The consensuality results are explained by the SCM, which also predicts a large number of new findings. The model assumes that in responding to a 2AFC item, participants sample a number of clues, and their confidence rests on self-consistency - the balance of evidence in favor of the chosen answer. Thus, *reliability* is used as a cue for *validity.* The pattern of results predicted by the SCM is that confidence should be higher for majority than for minority-answers, with the majority-minority difference in confidence increasing with the size of the majority - the probability of choosing the majority answer. This should be true regardless of the correctness of the answers (and regardless of any social influence). The predicted pattern has been confirmed across several tasks. In addition, in several studies in which the same items were presented on |several occasions the more frequent response was endorsed with higher confidence than the rare response, as predicted (see Koriat, 2012a, for a review). The results were very similar for perceptual judgments (Koriat, 2011) and general information (Koriat, 2008a), which is somewhat inconsistent with the claim that there is a fundamentally different basis for confidence in perception and in general knowledge (Dawes, 1980; Keren, 1988; Winman & Juslin, 1993).

A very similar pattern of results was obtained for response speed. Although confidence and response speed do not monitor (directly) the correctness of the response they proved to be powerful predictors of others' choices and behavior (Koriat, 2012b). The SCM also offers an explanation of the overconfidence bias: [participants' confidence is based on self-consistency (or reliability) whereas calibration is evaluated by researchers against a criterion of validity. However, reliability is virtually always higher than validity.

We examine next the role of confidence judgments in guiding control operations. First, it should be noted that the distinction between the MC and CM models holds true for confidence judgments as well. The results documenting a relationship between confidence and fluency are consistent with the assumption that confidence judgments are influenced by the feedback from control operations, for example the speed pith which an answer was retrieved or a solution was reached (Kelley & Lindsay, 1993; Topolinski, 2013). Confidence, however, also serves to guide control operations. Indeed, research indicates that confidence in a belief affects the likelihood of translating that belief into action (Gill et al., 1998). Thus, when participants were asked to wager on the correctness of their answer they relied heavily on their confidence pi/their answers and did so irrespective of the correctness of that answer (Fischhoff et al.,1977**;** Koriat, 2011). For example, in Koriat and Goldsmith's study (1996), when participants were allowed the option of withholding information likely to be wrong, the decision to volunteer or withhold an answer was based almost entirely on the subjective confidence in that answer: the correlation between confidence and volunteering (measured in two separate phases of the experiment) was remarkably high: .97 for recall and .93 for recognition.

Koriat, Ma'ayan et al. (2006, Experiment 7), using confidence in problem solving, Provided evidence for the MC and CM models occurring within the same task. When participants were given several problems to solve they invested more time in the problems that were associated with a higher incentive than in those that were associated with a lower incentive, and in parallel, reported higher confidence in the solutions of the former problems than in those of the latter problems (MC model). However, for each level of incentive confidence decreased with solution time, suggesting that confidence was based on the feedback from task performance (CM model).

These results highlight the importance of distinguishing between the effects of (data-driven effort and goal-driven effort on confidence judgments. Building on this distinction, Ackerman (2014) has recently proposed a Diminishing Criterion Model for problem-solving tasks. According to this model, people invest effort in a goal-driven manner, but the investment of more time on a problem leads to increased compromise on the goal, and this compromise is responsible in part for the negating time-confidence correlation observed.

Koriat and Goldsmith (1996; see Goldsmith & Koriat, 2008, for a review), proposed a theoretical model for the role of metacognitive monitoring and control processes in the strategic regulation of the quantity and accuracy of the information that people report from memory. Associated with this model is a Quantity-Accuracy Profile (QAP) methodology. The model assumes that rememberers, such as witnesses in court, do not simply report all of the information that comes to mind. Rather, when given the opportunity of “free-report,” they tend to report information that they are confident about and withhold information about which they are unsure. Because confidence is partly diagnostic of memory accuracy the exercise of report option was found to yield a quantity-accuracy trade-off: fewer items of information were reported but a larger proportion of these items were correct in comparison with forced-report questioning. One implication of the model and results is that courtroom witness who are sworn, “to tell the whole truth” (maximize quantity) and “nothing but the truth” (maximize accuracy), will generally be unable to do so - unless both their monitoring and their control processes operate perfectly. The more general implication of the framework is that actual memory performance depends not just on “memory” per se but also on the effectiveness of the monitoring and control processes that are used to identify and screen out false information during memory retrieval and reporting. The QAP methodology allows the cognitive and metacognitive contributions to be isolated and measured.

The theoretical framework of Koriat and Goldsmith (1996), which highlights the decisional processes involved in memory reporting, has been applied in many domains to elucidate such questions as the effectiveness of different questioning and testing procedures, changes in memory accuracy over time, the credibility of children’s witness testimony, and the assessment of psychometric and scholastic skills. The framework has been extended to include control over the grain size (precision or coarseness! of the information reported (Ackerman & Goldsmith, 2008; Goldsmith, Koriat, & Pansky, 2005; Goldsmith, Koriat, & Weinberg-Eliezer, 2002). Here too, metacognitive monitoring and control processes are used in regulating an informativeness accuracy trade-off.

Conclusions

In this chapter, I have presented a selective review of some of the work in metacognition that has some bearing on the traditional work on judgment and decision making. As was noted, research on metacognition has focused on the monitoring and regulation of one's own cognitive processes and behavior. However, the underlying processes have much in common with those studied in the context of judgment and decision making in general. At the same time, the study of metacognition has brought to the fore new ideas and findings. The establishment of metacognition as a topic of interest in its own right is already producing synergy between different areas of investigation including judgment and decision making, perception and psychophysics, and cognitive development. In addition, the increased interest in metacognition research derives in part from the feeling that perhaps this research can bring us closer to dealing with some of the metatheoretical issues that have been the province of philosophers of the mind.

Acknowledgments

The preparation of this chapter was supported by the Max Wertheimer Minerva Center for Cognitive Processes and Human Performance at the University of Haifa. I am grateful to Shiri Adiv for her assistance in preparing the chapter and to Miriam Gil for her help in the analyses. I also thank Etti Levran (Merkine) and Ornit Tsoury for their help in copy editing.

References

Ackerman, R. (2014). The Diminishing Criterion Model for metacognitive regulation of time investment. *Journal of Experimental Psychology: General, 143,* 1349-1368.

Ackerman, R., & Goldsmith, M. (2008). Control over grain size in memory reporting-with and without satisficing knowledge. *Journal of Experimental Psychology: Human Learning and Memory, 34,*1224-1245.

Alter, A. L., & Oppenheimer, D. M. (2009). Uniting the tribes of fluency to form metacognitive nation. *Personality and Social Psychology Review, 13,* 219-235.

Ariel, R, Dunlosky, J., & Bailey, H. (2009). Agenda-based regulation of study-time allocation: When agendas override item-based monitoring. *Journal of Experimental Psychology: General, 138,*432-447.

Benjamin, A. S., & Bjork, R. A. (1996). Retrieval fluency as a metacognitive index. In L. M. Reder (Ed.), *Implicit memory and metacognition* (pp. 309-338). Mahwah, NJ: Erlbaum.

Benjamin, A. S., Bjork, R. A., & Schwartz, B. L. (1998). The mismeasure of memory: When retrieval fluency is misleading as a metamnemonic index. *Journal of Experimental Psychology: General, 127,* 55-68.

Beran, M., Brandi, J. L., Perner, J., & Proust, J. (2012). *The foundations of metacognition.* Oxford, UK: Oxford University Press.

Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning: Beliefs, techniques, and illusions. *Annual Review of Psychology, 64,* 417-444.

Brewer, W. R, & Sampaio, C. (2006). Processes leading to confidence and accuracy in sentence recognition: A metamemory approach. *Memory, 14,* 540-552.

Brewer, W. F., & Sampaio, C. (2012). The metamemory approach to confidence: A test using semantic memory. *Journal of Memory and Language, 67, 59-77.*

Brown, A. S. (2012). *The tip of the tongue state.* New York, NY: Psychology Press.

Brown, R., & McNeill, D. (1966). The tip of the tongue phenomenon. *Journal of Verbal Learning and Verbal Behavior, 5,* 325-337.

Branswik, E. (1956). *Perception^ and the representative design of psychological experiments.* Berkeley, CA: University of California Press.

Carruthers, P. (2011). *Opacity of mind: An integrative theory of self-knowledge.* Oxford, UK: Oxford University Press.

Chaiken, S., & Trope, Y. (1999). *Dual process theories in social psychology.* New York, NY: The Guilford Press.

Chandler, C. C. (1994). Studying related pictures can reduce accuracy, but increase confidence in a modified recognition test. *Memory & Cognition, 22*, 273-280.

Cohen, R. L., Sandler, S. P., & Keglevich, L. (1991). The failure of memory monitoring in a free recall task. *Canadian Journal of Psychology, 45,* 523-538.

Costermans, J., Lories, G., & Ansay, C. (1992). Confidence level and feeling of knowing in question answering: The weight of inferential processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,*142-150.

Dawes, R. M. (1980). Confidence in intellectual judgments vs. confidence in perceptual] judgments. In E. D. Lanterman & H. Feger (Eds.), *Similarity and choice: Papers in the honor of Clyde Coombs* (pp. 327-345). Bern, Switzerland: Huber.

Dhami, M. K., Hertwig, R., & Hoffrage, U. (2004). The role of representative design in an ecological approach to cognition. *Psychological Bulletin, 130,* 959-988

Dunlosky, J., & Hertzog, C. (1998). Training programs to improve learning in later adulthopdi Helping older adults educate themselves. In D. J. Hacker, J. Dunlosky, & A. C. Gmesseia (Eds.), *Metacognition in educational theory and practice* (pp. 249-276). Mahwah, N.J.: Erlbaum.

Dunlosky, J., & Metcalfe, J. (2009). *Metacognition.* Thousand Oaks, CA: Sage.

Dunlosky, J., & Thiede, K. W. (1998). What makes people study more? An evaluation of factors that affect self-paced study. *Acta Psychologica, 98,* 37-56.

Dunlosky, J., & Thiede, K. W. (2004). Causes and constraints of the shift-to-easier-materials effect in the control of study. *Memory & Cognition, 32,* 779-788.

Dunning, D., Heath, C., & Suls, J. M. (2004). Flawed self-assessment. *Psychological Science, 5,*69-106.

Erev, I., Wallsten, T. S., & Budescu, D. V. (1994). Simultaneous over- and underconfidence. The role of error in judgment processes. *Psychological Review, 101,* 519-527.

Fischhoff, B. (1975). Hindsight is not equal to foresight: The effects of outcome knowledge judgment under uncertainty. *Journal of Experimental Psychology:*

Human Perception and. Performance, 1, 288-299.

Fischhoff, B., Slovic, P., 8c Lichtenstein, S. (1977). Knowing with certainty: The appropriateness of extreme confidence. *Journal of Experimental Psychology: Human Perception and Performance, 3,* 552-564.

Gardiner, J. M., & Richardson-Klavehn, A. (2000). Remembering and knowing. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 229-244). New York, NY: Oxford University Press.

Gigerenzer, G., Hoffrage, U., & Kleinbolting, H. (1991). Probabilistic mental models. A Brunswikian theory of confidence. *Psychological Review, 98,* 506-528.

Gill, M. J., Swann, W. B., Jr., & Silvera, D. H. (1998). On the genesis of confidence. *Journal of Personality and Social Psychology, 75,*1101-1114.

Goldsmith, M., & Koriat, A. (2008). The strategic regulation of memory accuracy and informativeness. In A. Benjamin & B. Ross (Eds.), *Psychology of Learning and Motivation, Vol 48: Memory use as skilled cognition* (pp. 1-60). San Diego, CA: Elsevier.

Goldsmith, M., Koriat, A., & Pansky, A. (2005). Strategic regulation of grain size in memorifc reporting over time. *Journal of Memory and Language (Special Issue on Meta memory) 52:* 505-525.

Goldsmith, M., Koriat, A., & Weinberg-Eliezer, A. (2002). The strategic regulation of graih: size in memory reporting. *Journal of Experimental Psychology: General, 131,* 73-95.

Griffin, D., & Brenner, L. (2004). Perspectives on probability judgment calibration In D. J. Koehler & N. Harvey (Eds.), *Blackwell handbook of judgment and decision making* (pp. 177-198). Oxford, UK: Blackwell.

Griffin, D., & Tversky, A. (1992). The weighing of evidence and the determinants of confidence. *Cognitive Psychology, 24,* 411-435.

Halamish, V., McGillivray, S., & Castel, A. D. (2011). Monitoring one's own forgetting in younger and older adults. *Psychology and Aging, 26,* 631-635.

Hall, C. C., Ariss, L., & Todorov, A. (2007). The illusion of knowledge: When more information reduces accuracy and increases confidence. *Organizational*

Behavior and Human Decision Processes, 103, 277-290.

Hart, J. T. (1965). Memory and the feeling-of-knowing experience. *Journal of Educational Psychology, 56,* 208-216.

Hasher, L., Goldstein, D., & Toppino, T. (1977). Frequency and the conference of referential validity. *Journal of Verbal Learning & Verbal Behavior, 16,* 107-112.

Hoffrage, U. (2004). Overconfidence. In R. F. Pohl (Ed.), *Cognitive illusions: Fallacies and biases in thinking, judgement, and memory* (pp. 235-254). Hove, UK: Psychology Press.

Jacoby, L. R., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General, 3,* 306-340.

James, W. (1884). What is an emotion? *Mind, 9,* 188-205.

Johnson, M. K. (1997). Identifying the origin of mental experience. In M. S. Myslobodsky (Ed.), *The mythomanias: The nature of deception and self-deception* (pp. 133-180). Hillsdale, NJ: Erlbaum.

Juslin, P. (1993). An explanation of the hard-easy effect in studies of realism of confidence in *f* one's general knowledge. *European Journal of Cognitive Psychology, 5,* 55-71.

Juslin, P. (1994). The overconfidence phenomenon as a consequence of informal experimenter- guided selection of almanac items. *Organizational Behavior and Human Decision Processes, 57,* 226-246.

Kahneman. D. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice Hall.

Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist, 58*, *697-720.*

Karpicke, J. D. (2009). Metacognitive control and strategy selection: Deciding to practice retrieval during learning. *Journal of Experimental Psychology: General, 138,*469-486.

Kelley, C. M., & Jacoby, L. L. (1996). Adult egocentrism: Subjective experience versus analytic bases for judgment. *Journal of Memory and Language, 351,* 7-75.

Kelley, C. M., & Lindsay, D. S. (1993). Remembering mistaken for knowing: Ease of retrieval as a basis for confidence in answers to general knowledge questions. *Journal of Memory and Language, 32,* 1-24.

Keren, G. (1988). On the ability of monitoring non-veridical perceptions and uncertain knowledge: Some calibration studies. *Acta Psychologica, 67,* 95-119.

Keren, G. (1991). Calibration and probability judgments: Conceptual and methodological issues. *Acta Psychologica, 77,* 217-273.

Koriat, A. (1976). Another look at the relationship between phonetic symbolism and the feeling of knowing. *Memory & Cognition, 4,* 244-248.

Koriat, A. (1993). How do we know that we know? The accessibility model of the feeling of knowing. *Psychological Review, 100(*4), 609-639.

Koriat, A. (1995). Dissociating knowing and the feeling of knowing: Further evidence for the p accessibility model. *Journal of Experimental Psychology: General, 124,* 311-333.

Koriat, A. (1997). Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning. *Journal of Experimental Psychology: General, 126,* 349-370.

Koriat, A. (2000). The feeling of knowing: Some metatheoretical implications for consciousness and control. *Special issue of Consciousness and Cognition, 9,* 149-171.

Koriat, A. (2007). Metacognition and consciousness. In P. D. Zelazo, M., Moscovitch, & E. Thompson (Eds.), *The Cambridge handbook of consciousness (pp.* 289-325). Cambridge, UK: Cambridge University Press.

Koriat, A. (2008a). Subjective confidence in one's answers: The consensuality principle. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 34,* 945-959.

Koriat, A. (2008b). When confidence in a choice is independent of which choice is made. *Psychonomic Bulletin and Review, 15,* 997-1001.

Koriat, A. (2011). Subjective confidence in perceptual judgments: A test of the self-consistency model. *Journal of Experimental Psychology: General, 140,* 117-139.

Koriat, A. (2012a). The self-consistency model of subjective confidence. *Psychological Review, 119,* 80-113.

Koriat, A. (2012b). When are two heads better than one and why? *Science, 336,* 360-362.

Koriat, A., & Ackerman, R. (2010). Choice latency as a cue for children's subjective confidence in the correctness of their answers. *Developmental Science, 13,* 441-453.

Koriat, A., Ackerman, R, Adiv, S., Lockl, K., & Schneider, W. (2013). The effects of goal- driven and data-driven regulation on metacognitive monitoring during learning. A developmental perspective. *Journal of Experimental Psychology: General, 143,* 386-403.

Koriat, A., Ben-Zur, H., & Druch, A. (1991). The contextualization of memory for input and output events. *Psychological Research, 53,* 260-270.

Koriat, A., Ben-Zur, H., & Sheffer, D. (1988). Telling the same story twice: Output monitoring and age. *Journal of Memory and Language, 27,* 23-39.

Koriat, A., & Bjork, R A. (2005). Illusions of competence in monitoring one's knowledge during study. *Journal of Experimental Psychology: Learning, Memory and Cognition, 31,* 187-194.

Koriat, A., & Bjork, R A. (2006a). Illusions of competence during study can be remedied by manipulations that enhance learners' sensitivity to retrieval conditions at test. *Memory & Cognition, 34,* 959-972.

Koriat, A., & Bjork, R A. (2006b). Mending metacognitive Musions: A comparison of mnemonic- based and theory-based procedures. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,*1133-1145.

Koriat, A., Bjork, R. A., Sheffer, L., & Bar, S. K. (2004). Predicting one's own forgetting: The role of experience-based and theory-based processes. *Journal of Experimental Psychology: General, 133,* 646-653.

Koriat, A., Fiedler, K, & Bjork, R. A. (2006). The inflation of conditional predictions. *Journal of Experimental Psychology: General, 135,* 429-447.

Koriat, A., & Goldsmith, M. (1996). Monitoring and control processes in the strategic regulation of memory accuracy. *Psychological Review, 103,* 490-517.

Koriat, A., & Levy-Sadot, R. (2001). The combined contributions of the cue-familiarity and accessibility heuristics to feelings of knowing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27,* 34-53.

Koriat. A., Levy-Sadot, R, Edry, E., & de Marcas, G. (2003). What do we know about what we cannot remember! Accessing the semantic attributes of words that cannot be recalled. *Journal of Experimental Psychology: Learning, Memory and Cognition, 29(6),* 1095-1105.

Koriat, A., Lichtenstein, S., & Fischhoff, B. (1980). Reasons for confidence. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 107-118.

Koriat, A., & Ma'ayan, H. (2005). The effects of encoding fluency and retrieval fluency on judgments of learning. *Journal of Memory and Language, 52,* 478-492.

Koriat, A., & Ma'ayan, H., Nussinson, R. (2006). The intricate relationships between monitoring and control in metacognition: Lessons for the cause-and-effect relation between subjective experience and behavior. *Journal of Experimental Psychology: General, 135,* 36-69.

Koriat, A., & Nussinson, R. (2009). Attributing study effort to data-driven and goal-driven effects: Implications for metacognitive judgments. *Journal of Experimental Psychology: Learning, Memory and Cognition, 35,* 1338-1343.

Koriat, A., Nussinson, R., Bless, H., & Shaked, N. (2008). Information-based and experience- based metacognitive judgments: Evidence from subjective confidence. In J. Dunlosky & R. A. Bjork (Eds.), *Handbook of memory and metamemory* (pp. 117—135). New York, NY: Psychology Press.

Koriat, A., Pansky, A., & Goldsmith, M. (2011). An output-bound perspective on false memories: The case of the Dcese-Roediger-McDermott (DRM) paradigm. In A. Benjamin (Ed.), *Successful remembering and successful forgetting* (pp. 297-323). London, UK: Psychology Press.

Koriat, A., Sheffer, L., & Ma'ayan, H. (2002). Comparing objective and subjective learning curves: Judgments of learning exhibit increased underconfidence with practice. *Journal of Experimental Psychology: General, 131,* 147-162.

Kornell, N., & Bjork, R. A. (2009). A stability bias in human memory: Overestimating remembering and underestimating learning. *Journal of Experimental Psychology: General, 138,* 449-468.

Leonesio, R. J., & Nelson, T. O. (1990). Do different metamemory judgmentstap the same underlying aspects of memory? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 464-470.

Lichtenstein, S., Fischhoff, B., & Phillips, L. D. (1982). Calibration of probabilities: The state of the art to 1980. In D. Kahneman, P. Slovic, & A. Tverskv (Eds.), *Judgment under uncertainty: Heuristics and biases* (pp. 306-334). New York, NY: Cambridge University Press.

Loussouarn, A., Gabriel, D., & Proust, J. (2011). Exploring the informational sources of metaperception: The case of change blindness blindness. *Consciousness and Cognition, 20,* 1489-1501.

Maki, R. H., & McGuire, M. J. (2002). Metacognition for text: Findings and implications for education. In T. Perfect & B. Schwartz (Eds.), *Applied Metacognition.* Cambridge, UK: Cambridge University Press.

Maki, W. S. (2007). Judgments of associative memory. *Cognitive Psychology, 54,* 319-353.

Metcalfe, J. (2002). Is study time allocated selectively to a region of proximal learning? *Journal of Experimental Psychology: General, 131,* 349-363.

Metcalfe, J., & Kornell, N. (2003). The dynamics of learning and allocation of study time to a region of proximal learning. *Journal of Experimental Psychology: General, 132,* 530-542.

Metcalfe, J., Schwartz, B. L., & Joaquim, S. G. (1993). The cue-familiarity heuristic in metacognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 19, 851-864.

Mickes, L., Hwe, V., Wais, P. E., & Wixted, J. T. (2011). Strong memories are hard to scale. *Journal of Experimental Psychology: General, 140,* 239-257.

Mueller, M. L., Tauber, S. K., & Dunlosky, J. (2013). Contributions of beliefs and processing fluency to the effect of relatedness on judgments of learning.

Psychonomic Bulletin & Review, 20, 378-384.

Nelson, T. O., & Dunlosky, J. (1991). When people's judgments of learning (JOLs) are extremely accurate at predicting subsequent recall: The "delayed-JOL effect." *Psychological Science, 2,* 267-270.

Nelson, T. O., & Leonesio, R. J. (1988). Allocation of self-paced study time and the "labor-in-vain effect." *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 676-686.

Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In G. H. Bower (Ed.), *The psychology of learning and motivation* (pp. 1-45). New York, NY: Academic Press.

Proust, J. (2013). *The philosophy of metacognition: Mental agency and self-awareness.* Oxford, UK: Oxford University Press.

Reder, L. M. (1988). Strategic control of retrieval strategies. In G. H. Bower (Ed.), *The psychology of learning and motivation*, (Vol. 22, pp. 227-259). New York, NY: Academic Press.

Rhodes, M. G., & Castel, A. D. (2008). Memory predictions are influenced by perceptual: information: Evidence for metacognitive illusions. *Journal of Experimental Psychology General*, *137*, 615-625.

Robinson, M. D., Johnson, J. T., & Herndon, F. (1997). Reaction time and assessments of cognitive effort as predictors of eyewitness memory accuracy and confidence. *Journal of Applied Psychology, 82,* 416-425.

Roediger, H. L., Ill, Wixted, J. H., & DeSoto, K A. (2012). The curious complexity between confidence and accuracy in reports from memory. In L. Nadel & W. Sinnott-Armstrong (Eds.), *Memory and law* (pp. 84-118). Oxford, UK: Oxford University Press.

Shaw, J. S., III. (1996). Increases in eyewitness confidence resulting from post event questioning. *Journal of Experimental Psychology: Applied, 2,* 126-146.

Schwartz, B. L. (1998). Illusory tip-of-the-tongue states. *Memory, 6,* 623-642.

Schwartz, B. L. (2001). The relation of tip-of-the-tongue states and retrieval time. *Memory & Cognition, 29,*117-126.

Schwartz, B. L., & Metcalfe, J. (1992). Cue familiarity but not target retrievability enhances feeling-of-knowing judgments. *Journal of Experimental Psychology: Learning*, *Memory, and Cognition, 18,* 1074-1083.

Schwarz, N. (2015). Metacognition. In M. Mikulincer, P. R. Shaver, E. Borgida, & J. A. Bargh (Eds.), *APA handbook of personality and social psychology: Attitudes and social cognition*« (pp. 203-229). Washington, DC: APA.

Schwarz, N., Bless, H., Strack, F., Klumpp, G., Rittenauer-Schatka, H., & Simons, A. (1991). Ease of retrieval as information: Another look at the availability heuristic. *Journal of Personality and Social Psychology, 61,* 195-202.

Schwarz, N., & Clore, G. L. (2007). Feelings and phenomenal experiences. In A. Kruglanski & E. T. Higgins (Eds.), *Social psychology: Handbook of basic principles* (2nd ed*.,* pp. 385-407). New York, NY: Guilford Press.

Son, L. K., & Metcalfe, J. (2000). Metacognitive and control strategies in study-time allocation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26,* 204-221.

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8,* 220-247.

Teigen, K. H. (1983). Studies in subjective probability III: The unimportance of alternatives? *Scandinavian Journal of Psychology, 24,* 97-195.

Thiede, K. W., Anderson, M. C. M., & Therriault, D. (2003). Accuracy of metacognitive monitoring affects learning of texts*. Journal of Educational Psychology, 95,* 66-73.

Thiede, K W., & Dunlosky, J. (1999). Toward a general model of self-regulated study: An analysis of selection of items for study and self-paced study time. *Journal of Experimental) Psychology: Learning, Memory, and Cognition, 25,* 1024-1037.

Topolinski, S. (2013). The sources of fluency: Identifying the underlying mechanisms of fluency effects. In C. Unkelbach & R. Greifeneder (Eds.), *The experience of thinking* (pp. 33-49). New York, NY: Psychology Press.

Undorf, M., & Erdfelder, E. (2013). Separation of encoding fluency and item difficulty effects on judgements of learning. *The Quarterly Journal of Experimental*

Psychology, 66, 2060-2072.

Unkelbach, C. (2006). The learned interpretation of cognitive fluency. *Psychological Science, 17,* 339-345.

Unkelbach, C., & Greifeneder, R. (2013a). A general model of fluency effects in judgment and decision making In C. Unkelbach & R. Greifeneder (Eds.), *The experience of thinking* (pp. 11-32). New York, NY: Psychology Press.

Unkelbach, C., & Greifeneder, R. (2013a). A general model of fluency effects in judgment and decision making. In C. Unkelbach & R. Greifeneder (Eds.), *The experience of thinking* (pp. 11-32). New York, NY: Psychology Press.

Unkelbach, C., & Greifeneder, R. (Eds.) (2013b). *The experience of thinking.* New York, NY: Psychology Press.

Van Zandt, T. (2000). ROC curves and confidence judgments in recognition memory. *Journal of Experimental Psychology: Learning, Memory, and, Cognition, 26,* 582-600.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review, 92,* 548-573.

Winman, A., & Juslin, P. (1993). Calibration of sensory and cognitive judgments: Two different accounts. *Scandinavian Journal of Psychology, 34,* 135-148.