The influence of overconfidence on decision-making and medical diagnosis

Guido Huisman
Erasmus University

Abstract

This narrative review analyzes the concept of overconfidence. By combining literature from the fields of psychology and medicine, this narrative review sheds light on the phenomenon of overconfidence, its influences on decision-making and its influence on the diagnostic process. Overconfidence appears to be a multi-faceted construct influenced by a variety factors, such as personality, motivation and cognitive factors. Overconfidence can be detrimental to effective decision-making, as it influences the way people use information and it makes people prone to various cognitive biases. In the diagnostic process, these biases could lead to noncompliance to guidelines and missed diagnoses. Potentially, this physician overconfidence can be combatted with educational techniques such as de-biasing or feedback, but there is not enough research on the efficacy of such methods in the medical world.

Keywords: overconfidence, diagnostic errors, medical diagnosis, biases, decision making

The influence of overconfidence on decision-making and medical diagnoses

This paper will address the concept of overconfidence as a universal trait in humans and more specifically, it's influence on decision making in medical diagnosis. Overconfidence can be described as a discrepancy between a person's confidence in a certain skill and their actual skill level. It is a phenomenon that has frequently been found in various demographic groups and a variety of tasks. Infamously, Svenson found that in his study on driving competence, the majority of his sample believed they were better drivers than the average person (Svenson, 1981). Although such a finding is conceivable within a negatively skewed distribution, it intuitively contradicts fundamental statistics. Moreover, this 'illusory superiority' has been found in a wide array of skills and characteristics, from driving to personality traits (Brown, 2012) to teaching skills (Patricia Cross, 1977).

It is perhaps unsurprising that humans have a tendency to overrate their own skills as this can play a vital role in maintaining one's self-esteem and preserving optimism (Baumeister, Heatherton, & Tice, 1993). Indeed, studies have found that non-depressed people tend to overrate themselves and underrate others, whereas this pattern is reversed for depressed people (Kuiper & MacDonald, 1982). Over-estimation of oneself can thus act as a mental defense mechanism that protects one's ego. In many cases, this phenomenon is likely to be relatively harmless and can even be beneficial.

However, how common is overconfidence really and what happens when overconfidence interferes with people's abilities to make decisions? Moreover, how is the judgment of medical doctors, who make life altering decisions for their patients on a daily basis, altered by this inflated sense of ability? These are the questions this paper will try to answer.

Answering these questions is of great societal relevance for a number of reasons. First of all, many have argued that overconfidence might be partially to blame for some of history's most severe tragedies, including the Iraq war and even the First World War (Jonhson & Levin, 2009). Secondly, diagnostic errors with consequences for patients can occur due to overconfidence. For example, in mammography it has been estimated that 10-30% of breast cancers are missed (Berner & L. Graber, 2008). If overconfidence can impair such decision making, it is vital to understand how and when doctors are influenced by overconfidence and what they can do to shield themselves from it.

In sum, this paper will delve into the concept of overconfidence and its effects on decision-making in general and decision making in medicine specifically. Literature from both the fields of psychology and medicine will be combined to create a comprehensive overview of various aspects of overconfidence. The first segment will focus on the etiology of overconfidence. The second segment analyzes the effects that overconfidence can have on decision making. Finally, the last segment discusses how overconfident decision making impairs diagnostics and medical decision making.

Method

A systematic literature search was conducted. Literature was searched with the search engines PubMed, Scopus, PsycINFO, PsycNET and Google Scholar, using a variety of keyword combinations relating to the topics that were researched. These keywords were *overconfidence, personality, causes, prevalence, better-than-average, brain, etiology, beliefs, definition, traits, motivation, decision-making, biases, information, decisions, heuristics, type 1/type 2 processing, system 1/system 1 processing, groupthink, dunning-kruger, feedback dual-process theory, error, diagnostic, medicine, reducing, feedback, decision-support system* . Boolean search operators were used to make combinations between the keywords. When the search engine allowed for it, the subject area of the journal was limited to the fields of psychology and medicine. Below is an example of the search input in Scopus:

(TITLE-ABS-KEY(overconfidence) OR TITLE-ABS-KEY(overconfidence AND personality) OR TITLE-ABS-KEY(overconfidence AND causes) OR TITLE-ABS-KEY(better-than-average) OR TITLE-ABS-KEY(overconfidence AND brain) OR TITLE-ABS-KEY(overconfidence AND etiology) OR TITLE-ABS-KEY(overconfidence AND definition) OR TITLE-ABS-KEY(overconfidence AND traits) AND TITLE-ABS-KEY(overconfidence AND beliefs) OR TITLE-ABS-KEY(overconfidence AND motivation) OR TITLE-ABS-KEY(overconfidence AND decision-making) OR TITLE-ABS-KEY(decision-making AND biases) OR TITLE-ABS-KEY(decision-making AND information) OR TITLE-ABS-KEY(groupthink) OR TITLE-ABS-KEY(decisions) OR TITLE-ABS-KEY(dunning-kruger) OR TITLE-ABS-KEY(type 1 type 2 AND processing) OR TITLE-ABS-KEY(type 1 AND overconfidence) OR TITLE-ABS-KEY(system 1 system 2 AND processing) OR TITLE-ABS-KEY(system 1 AND overconfidence) OR TITLE-ABS-KEY(dual-process theory AND overconfidence) OR TITLE-ABS-KEY(dual-process AND theory) AND TITLE-ABS-KEY(diagnostic AND error) OR TITLE-ABS-KEY(overconfidence AND error) OR TITLE-ABS-KEY(decision-making AND medicine) OR TITLE-ABS-KEY(overconfidence AND medicine) OR TITLE-ABS-KEY(overconfidence AND medical AND feedback) OR TITLE-ABS-KEY(reducing AND overconfidence) OR TITLE-ABS-KEY(diagnostic* AND biases) OR TITLE-ABS-KEY(heuristics) OR TITLE-ABS-KEY(decision-support system)) AND (LIMIT-TO (SUBJAREA,"PSYC") OR LIMIT-TO (SUBJAREA,"MEDI") OR LIMIT-TO (SUBJAREA,"SOCI")

The search input used differed between search engines, since not all engines have the same filters. We did not limit the range of year of publishing, but the literature was required to be in English. Since the search input still led to an abundance of literature, the articles were screened for relevance. This was done firstly by reading the titles, which excluded literature that was beyond the scope of this article (e.g. entrepreneurial/ military contexts) or literature that did not pertain to the topics of this article. Subsequently, the abstracts of the remaining articles were read to ascertain whether the source contained information or an experiment that would help in answering one of the research questions. Information was deemed relevant if it pertained to the etiology of overconfidence, the influence of overconfidence on decision-making or the influence of overconfidence on diagnostic decision-making. If a source contained valuable information overall it was read in its entirety. If a source was used to refer only to one specific idea or finding, only the parts of a source that were valuable for this article were read. The reading of the literature led to some additional sources by referent. Eventually, 57 articles were selected as valuable for this article.

Section I: Definition & Etiology of Overconfidence

Definition

According to Johnson & Fowler, overconfidence is one of the most consistent and widespread biases that humans show (Jonhson & Fowler, 2011). Their article defines overconfidence as: 'an overestimation of one's capabilities or an underestimation of other's abilities, the difficulty of a task or the risks involved'. This definition is similar to how the majority of studies on overconfidence define the concept, and this definition will be used in the current article.

However, there is a case to be made that overconfidence is merely an umbrella term for several underlying constructs, and that researchers often confound these. For example, Moore & Healy mention that psychological literature generally concerns three different types of overconfidence (Moore & Healy, 2008). The first type entails the overestimation of one's performance or ability, or the level of control someone exerts over a situation. This type is appropriately titled *overestimation.* The second type, *overplacement,* resembles the previously mentioned better-than-average effect, a tendency for people to think they are better than others. The third type of overconfidence mentioned is *overprecision*, which is the tendency for people to overestimate the precision of their answers. Moore & Healy correctly point out that research on overconfidence sometimes produces inconsistent results. An example of such an inconsistency is *hard-easy effect*, which entails that overconfidence tends to be found on hard tasks while under confidence tends to be found on easy tasks. Although this effect is present in plenty of studies on overconfidence, there are examples, most notable in visual tasks, where the effect has not always been observed (Harvey, 1997). Moore & Healy mention three problems that arise in the study of overconfidence. Firstly, many researchers confound overestimation and overprecision. Secondly, underconfidence is often not taking into consideration. Lastly, they point at an inconsistency in research caused by the fact that easy tasks tend to produce the most underestimation yet also the most overplacement, whereas difficult tasks produce the most overestimation yet also the most underplacement (Moore & Healy, 2008).

It is therefore important to realize that many studies on overconfidence indeed do not address the differences between these types of overconfidence, which can lead to contradicting results. Moreover, overconfidence in diagnostic errors, which is topic of the 3rd section of this article, is often influenced by a combination of the 3 types.

Etiology of Overconfidence

Plenty of research has been dedicated to finding out which people are most likely to be overconfident and what conditions are most likely to induce overconfidence. Researchers tend to view overconfidence through different scopes. For example, in cognitive psychology overconfidence is seen either as the product of a multitude of biases, or is considered to be a bias itself. Since the cognitive perspective ties in directly with people's decision-making processes, they will be reviewed further in the 2nd section of this article. Other research however, has viewed overconfidence from the perspective that it is rooted not (only) in cognitive factors, but in personality, motivation, biology or even evolution.

Personality traits. Several studies have explored whether certain personality traits are related to overconfidence. In psychology, discussions regarding personality traits almost invariably contain 'the big five', which is appropriately named after the finding that many personality sub-traits or behaviors can eventually be reduced to one the following five traits: Neuroticism, Agreeableness, Extraversion, Conscientiousness, Openness to experience. In a study by Schaefer et al., 104 participants completed a task that measured overconfidence and were subsequently asked questions that determined their personality in terms of the big five taxonomy (Schaefer, Williams, Goodie, & Campbell, 2004). It was found that participants who scored high on extraversion were more likely to be overconfident, whereas openness to experience was positively related to both accuracy and confidence (i.e. better calibration between confidence and accuracy).

Another personality trait that has been linked to overconfidence is narcissism. Narcissism is a personality variable characterized by an exaggerated positive view of the self, and a tendency to continuously maintain or enhance this view (Campbell, Goodie, & Foster, 2004). In psychology, discussions on narcissism often concerns extreme cases, such as in cases of *narcissistic personality disorder* (NDP), a DSM acknowledged disorder (Levy, Reynoso, Wasserman, & Clarkin, 2007) Nonetheless, narcissism is a continuous personality variable that anyone possesses, although in varying intensities. Given the description of narcissism, it is conceivable that high levels of this personality trait can lead to overconfidence. This is indeed what was found in an experiment that compared narcissistic to less narcissistic people (Campbell, Goodie, & Foster, 2004). The study assessed 104 participants on narcissism using the NPI, a measure of narcissism in normal (i.e. not diagnosed with NPD) populations.

Subsequently, participants answered general knowledge questions and were polled after each question how confident they felt that their answer was correct. The results show a correlation between narcissism and overconfidence of $r = 0.28$, which is considered a low to moderate strength correlation in social science (De Vaus, 2002).

Beliefs and motivation. Interestingly, it has been found that in addition to personality traits, motivation and beliefs can also play a pivotal role in causing overconfidence. This idea was explored by Erhlinger et al. in a study that featured multiple experiments (Ehrlinger & Mitchumb, 2016). The first experiment explored the relation between a classic self-theory and overconfidence. 53 university students were surveyed on their beliefs of intelligence to determine whether they believed intelligence is fixed and unchangeable (*the entity theory of intelligence*) or that intelligence can be changed through practice and effort (*the incremental theory of intelligence*). Subsequently, participants were tested on multiple choice antonym problems and rated how confident they were that their answers were accurate. The results showed that participants that held entity views of intelligence were more overconfident than participants that believed in the incremental view of intelligence. Supposedly, this stems from the fact that people that believe intelligence is malleable are open to both positive and negative feedback because they perceive negative feedback to be points of improvement (Ehrlinger & Mitchumb, 2016). To obtain an honest reflection of one's performance, it is vital to be open to both positive and negative feedback. People who do not believe intelligence is malleable are not as likely to accept negative feedback since they believe there is little they can do to improve their performance. A follow-up experiment manipulated the participants' intelligence theory, by making them read either a passage on intelligence being malleable (incremental condition) or a passage on intelligence being fixed (entity condition). It was found that the manipulation successfully reduced or increased overconfidence depending on condition, which appeared to be mediated by the fact that participants in the entity condition allocated their attention away from difficult parts of the task and towards easy parts. The last experiment sought to also manipulate this allocation of attention, and found that this manipulation also reduced overconfidence. Overall, the study highlights that having an entity view of intelligence can make a person overconfident, which is mediated by an allocation away from difficult tasks. Fortunately, overconfidence can be reduced by manipulating either people's self-theory of intelligence or their allocation of attention.

It has also been suggested that overconfidence, particularly the overplacement type, is a bias that people possess to maintain positive self-esteem (Chambers & Windschitl, 2004). As mentioned previously, the tendency to overrate oneself might even shield a person from depression (Kuiper & MacDonald, 1982). Moreover, in an experiment conducted by Brown, participants were polled on how they would describe themselves and other people on ten different attributes, including honesty, kindness and intelligence (Brown, 2012). Participants were also asked how important they consider each of these attributes to be. The results reveal a clear pattern: when a person finds a particular attribute important, he/she is more likely to overplace themselves on that attribute compared to other people. A subsequent experiment in the same study set out to prove a causal inference between importance and overplacement, by experimentally manipulating the importance of attributes (Brown, 2012). This was done by changing the information participants received: in the high importance condition, they were told that the attributes were considered important and desirable, whereas in the low importance condition they were told the traits were ordinary and common. It was found that participants in the high importance condition overplaced themselves more than participants in the low importance condition. It appears that people are most overconfident on attributes when they believe those are important, and it is possible to manipulate this perceived importance.

Additional factors. In addition to the previously explored causes of overconfidence, there are some additional factors that deserve mention. Culture is one of them. It has been found that national averages on cognitive tasks vary widely between countries, while confidence in accuracy on those tasks is relatively the same across countries (Stankov & Lee, 2014). From this it follows that in countries with low national averages on cognitive tasks people tend to overestimate their performance. Moreover, a specific cultural finding is that on general knowledge questions, people from Asian countries tend to be more overconfident than people from Western countries (Yates, Lee, & Shinotsuka, 1996). Evolution has also been mentioned as an explanation for overconfidence. For example, Johnson & Fowler hypothesize that overconfidence is a product of natural selection, in that overconfidence would cater to faster and easier decision making (Johnson & Fowler, 2011). They present an economically centered model that assumes there can be material rewards associated with holding incorrect beliefs about one's performance. In a similar way, Li, Szolnoki, Cong and Wang argue that when resources are

scarce and people have to compete for them, bluffing and other overconfident behaviors might lead to an evolutionary advantage. (Li, Szolnoki, Cong, & Wang, 2016).

Additionally, it has been found that having high levels of confidence is neurally reinforcing. In a 2016 fMRI study that scanned participants while they performed metacognitive assessments, it was found that lower confidence was associated with activation of the orbitofrontal cortex, whereas a high level of confidence was associated with activation in the bilateral striatum (Molenberghs, Traitwein, Böckler, Singer, & Kanske, 2016). The orbitofrontal cortex has previously been associated with feelings of displeasure. The striatum on the other hand, is host of the caudate nuclei which are recognized as the location of the stimulus-action-reward association, an association that reinforces human actions through dopaminergic stimulation (Haruno & Kawato, 2006). It turns out that functions of the human brain make the sensation of confidence a naturally pleasurable experience, while feeling less confident is an inherently unpleasant experience.

Criticism. It is noteworthy to mention that although ample research has explored the concept of overconfidence, some researchers have made objections to its mere existence. For example, several researchers have stated that overconfidence is a merely an illusionary product of methodological and/or statistical artifacts (Ayton & McClelland, 1997). Supposedly, both overconfidence and underconfidence (i.e. underplacement, underestimation or underprecision) can be seen as random sampling error or can be the result of inappropriate sampling of test items. However, most literature on this debate stems from around the late 90's, and in present times the majority of researchers seem to conclude that overconfidence is a real and problematic phenomenon. Therefore, the rest of this article will not concern these objections.

Conclusion Section I. This section defined overconfidence and explored some potential reasons as to why people are overconfident, who is likely to be overconfident and which situations induce overconfidence. In sum, overconfidence has been linked to personality traits such as extraversion and/or narcissism. Moreover, the beliefs that people hold can alter the calibration between their confidence and their accuracy. People might also be deliberately motivated to be overconfident, as it is a pleasurable experience reinforced by human brain functions and it can help preserve self-esteem. Culture and evolution have also been mentioned as factors. Overconfidence appears to be a very multi-faceted construct that that can be looked at from varying perspectives. It is by no means clear how much weight should be given to each of

these perspectives or which variables are the main cause of overconfidence. As with many psychological constructs, there are many potential confounds and alternative explanations. Section II will address how overconfidence can influence decision-making abilities.

Section II: Overconfidence and decision making

Consequences of overconfident decisions

Historically, overconfidence has been blamed for many catastrophic decisions. These include decisions made by groups of people as well as decision made on an individual level. For example, overconfidence has been linked to *groupthink*, a phenomenon in which the opinions of a decision-making group drastically polarize due to a desire to maintain harmony in a group (Janis, 1991). This desire for harmony results in a collective overconfidence of sorts in which a group overestimates itself. The result is an inability to evaluate decisions and their consequences properly. Groupthink is often mentioned in discussion of the Colombia shuttle crisis, in which overconfident decision-making led to the death of 7 astronauts. “We thought we were better than we were”, “We became overconfident” are two literal quotes from group members that were involved in the crisis (Wall, 2013). The case clearly highlights that overconfidence can tamper with people’s ability to make sound decisions.

Unfortunately, groupthink is merely one example of how overconfidence pollutes people’s ability to make sound decisions. For example, in students it has been found that overconfidence leads to lower retention of study material, due to the fact that overconfident students stop studying before fully mastering the material (Dunlosky & Rawson, 2012). There is also an abundance of literature from the financial sector concerning the dangers of overconfident decisions. Many investors tend to be unjustifiably optimistic that their investments will increase in value. This investor overconfidence results in speculative bubbles, and is regarded as an explanation for both the dot-com crash of 2000 (Scheinkman & Xion, 2003), as well as overly optimistic investments in the cryptocurrency market (Craggs & Rashid, 2016). What’s noteworthy is that both events concerned markets that were poorly understood and thus brought about uncertainty. As we will see later, this is not the only example of uncertainty inducing overconfident decision-making.

Cognitive biases in decision-making

Overconfident decision-making has been linked to some fundamental cognitive biases that are well documented in the psychological literature. To understand this, we must first address how people process information in order to make a decision in the first place. One of the most well established theories on information processing is dual-process theory. This theory states that people have two cognitive systems that process information, system 1 and system 2 (Evans & Stanovich, 2013). The first system concerns fast-paced, unconscious automatic actions and decision-making, whereas the second system concerns slow, effortful and conscious decision-making and actions. System 1 resembles the use of *heuristics*, which are efficient and simple rules that can be used to solve problems that do not require deliberate effort (Frankish, 2010). On the other hand, when a task is novel, difficult or requires deliberate abstraction, there is a tendency for people to rely on system 2 processing (Evans & Stanovich, 2013). After all, in an unpracticed skill a person has yet to develop the automatic processing of system 1. Eventually, as a person gains more experience in a certain task, a skill can 'automatize', meaning system 1 processing takes over from system 2 processing. The tendency for people to rely on the heuristics and shortcuts that system 1 provides will often lead to a satisfying answer quickly. However, an overreliance on system 1 thinking can make a person vulnerable to a variety of cognitive biases that can lead to overestimation of one's skills or probabilities of certain outcomes (Croskerry & Norman, 2008). Some well-documented biases that can induce overconfident decision-making are confirmation bias, hindsight bias and the dunning-kruger effect. In *confirmation bias,* there is a tendency for people to seek evidence that confirms a person's initial idea about something and ignore evidence that counters that idea (Berner & Graber, 2008). As we will see in the last section of this article, this bias is a common pitfall in medical decision-making. The *dunning-kruger* effect is a bias that is also relevant in the study of overconfidence. In this bias, individuals of low competence in a certain skill are unable to critically look at their own ability (low meta-cognitive ability) due to that same lack of competence (Dunning, The Dunning–Kruger Effect: On Being Ignorant of One's Own Ignorance, 2011). To put it simple, it is difficult to know what you don't know when you don't know it, resulting in a vicious cycle of lack of self-awareness. *Hindsight* bias is the tendency to evaluate the probability of a certain event after it happened, which can also result in overconfidence in a diagnostic decision-making (Croskerry & Norman, 2008).

Factors leading to System 1 processing

There are a number of cases in which people are prone to use System 1 processing, making them more susceptible to the discussed biases. As mentioned, if a person is more experienced in a certain task, the process of that task is likely to automatize and become System 1 processing overtime. Moreover, it has been found that affective reactions directly after perception of a stimulus do not require higher cognitive operations (i.e. do not require System 2 processing), and these judgments are also made with greater confidence (Zajonc, 1980). Another experiment investigated how two types of spatial attention, endogenous and exogenous, were related to decision-making (Kurtz, Shapcott, Kaiser, Schmiedt, & Schmid, 2017). Endogenous attention entails attention that is voluntarily deployed whereas exogenous attention is an attention reflex to stimuli. Although this is reminiscent of a System 1/System 2 processing distinction, the results of Kurtz experiment reveal an opposite pattern: on an orientation-matching task it was found that endogenous, but not exogenous attention was related to higher confidence ratings. In spatial attention, confidence is thus related to attention that is actively deployed.

Another factor that can decide what type of processing is used is mood, which is an effect that can be highly specific. For example, sadness has been shown to promote systematic processing (System 2), whereas anger promotes heuristics processing (System 1) (Tiedens & Linton, 2001). An experiment by Tiedens & Linton discovered that the relationship between processing type and mood is mediated by how much certainty an emotion brings along. Anger, disgust, happiness and contentment give people a sense of certainty, while surprise, fear, worry and sadness induce a state of uncertainty. In four experiments, it was found that emotional states that related to certainty led to greater reliance on superficial cues from the environment, less attention to the quality of argument in a persuasive marketing message and more stereotype thinking (Tiedens & Linton, 2001). The authors conclude that emotions that bring along certainty can induce heuristic processing.

Use of information resources

It appears that overconfidence influences the way people utilize information to make a decision. In a classic experiment conducted by Oskamp, a sample of psychologists and psychology students were asked to analyze a case that was supposed to be representative of a normal clinical case (Oskamp, 1965). The participants moved through four stages and during each stage they received more background material about the case, similar to a clinical psychologist who obtains more information about a client as they have more interactions. While

going through the stages, participants answered multiple choice questions about the case and were asked how confident they felt about their answers. The study highlights a finding that has generalized to other contexts. Specifically, it was found that gaining more information did little to improve the accuracy of their judgment. However, as participants moved from stage 1 to stage 4, their confidence level increased from 33% to 53%, thus constituting to an increase in overconfidence. Moreover, as more information was presented, participants were less likely to change their previous answers. According to Oskamp, this suggests that the judges may have formed stereotype from the first information available to them, and that subsequent information were seen as confirmation for that stereotype conclusion, even if it was not (Oskamp, 1965). As mentioned previously, stereotype thinking is typical of the heuristics of System 1 processing (Tiedens & Linton, 2001).

In a perceptual decision task, Desender, Boldt & Yeung found an effect that is perhaps unexpected given what was found in the Oskamp study. Twenty participants performed a perceptual decision task in which they made categorical judgments of multi-item displays (Desender, Boldt, & Yeung, 2018). For example, a task would contain 8 items with differing colors, and the participant had to decide what the average color of the items is. It is commonly found that when the items have more variability (e.g. various items that are either completely red or completely blue) participants will have lower confidence in their accuracy. The study created conditions that altered the perceived accuracy on the task but not the actual accuracy. The results show that participants who were given items with more variability were less confident, and they were also more likely to consult additional information (ask to see the stimulus again) before making a decision. In other words, the tendency to seek out additional information was related only to subjective confidence but not to actual accuracy of performance. We see an example here of uncertainty not inducing overconfidence as in the Oskamp study, but rather a tendency to seek out more information. The tendency for difficult or uncertain tasks to induce overconfidence has not always been found in visual tasks (Harvey, 1997), which might explain why the studies of Oskamp and Desender provide different results.

Mediating variables in overconfident decision-making

Studies have investigated mediating variables in the relation between overconfidence and decision-making. For example, Paese & Sniezek analyzed four variables that they hypothesized to influence the confidence people have in their judgments (Paese & Sniezek, 1991). These four

variables are practice, effort, availability of relevant information, and decision-making. To elaborate, Paese & Sniezek argue that when people assess the correctness of their own judgment, they consider how much practice they have had with making such judgments, how much effort they already have invested in that task, how much relevant information is available to make the judgment and whether or not the judgment will be the basis for another decision (e.g. a doctor who's judgment leads to a diagnosis). In a personnel selection simulation, participants were asked to estimate the current and predicted level of performance of baseball pitchers, and were subsequently polled on how confident they felt in their assessment. Afterwards, they had to make a decision as to whether they would hire the baseball player or not. Participants were placed in a variety of conditions that manipulated the practice, effort, information and decision-making variables. It was found that with more practice, accuracy of estimations remained the same but confidence increased, leading to more overconfidence especially for predictive estimations. What's crucial here is that during trails there was an absence of feedback, showing that not being able to measure one's performance leads to an uncertainty that expresses as overconfidence. On the other hand, overconfidence was lower when judgments were to be the basis for a decision on whether the player should be hired or not, but only when this decision was made before assessing confidence in judgment. This is a sobering result, since it displays that people are more critical of their judgment when they know it's incorporated into a decision. Self-reported effort was related to an increase in both accuracy and confidence for current estimates, whereas in predictive estimates only confidence increased but not accuracy (Paese & Sniezek, 1991). Predictive estimates are another case of uncertainty leading to overconfidence.

An experiment by Chip & Gonzalez found that interacting with other people before making a decision can lead to overconfident decision making (Chip & Gonzalez, 1995). Their experiment also revealed a number of interesting findings on how people make decisions in the first place. The study's participants were specifically selected for their knowledge on the topic of football. They were asked to make predictions on the outcome of certain football matches and were polled for their confidence in those predictions. Subsequently, every participant was matched to have an interaction with another participant. The interaction was designed to be a conversation in which both participants can share their opinions and information. After this interaction, participants were once again asked for their predictions and confidence in their accuracy. It was found that after the interaction, participants increased in confidence in the

accuracy of their prediction, even if they had interacted with a participant that did not agree with their prediction. This increase in confidence was not met by an equal increase in accuracy of the prediction, thus leading to overconfidence. This finding contradicts with *Persuasive Arguments Theory;* the idea that receiving information from another person before making a decision will lead to better decision-making (Chip & Gonzalez, 1995), even though that theory is frequently mentioned as a factor in groupthink and overconfident group decision-making (Myers, 2007). The finding is also in line with what the Oskamp study found; more information resources lead to higher overconfidence but not higher accuracy.

Conclusion section II

Overconfident decision-making has been linked to a variety of cognitive biases that are robust and are observed in different contexts. There also appears to be a reciprocal interaction between overconfidence and the way people utilize information resources, which is also shown by the finding that overconfidence increases when people discuss their ideas with others. Under some conditions, uncertainty and difficulty induce overconfident decision-making, while in other contexts it does not. Section III will explore how overconfident decisions impact diagnostic errors.

Section III: Overconfidence in medical diagnosis

Prevalence of diagnostic errors

On a daily basis, doctors need to make decisions that can be life-altering for their patients. Yet, at the end of the day doctors are only human and it would be unreasonable to expect that they are flawless decision makers. Nonetheless, anything possible should be done to guard doctors from the biases that flaw human decision making, especially if they are preventable. Given the importance of proper health care, plenty of research has been dedicated to medical errors, some of which pertain to the diagnostic process. A diagnostic error can be defined as any mistake or failure in the diagnostic process that leads to a misdiagnosis, a missed diagnosis or a delayed diagnosis (Gordon D. Schiff, Omar Hasan, Seijeoung Kim, Richard Abrams, & Karen Cosby, 2009). In a much cited article by Elstein, the rate of diagnostic errors in medicine overall was estimated to be as high 15% (Elstein, 1995). Although a 15% overall error rate might be forgivable in some disciplines, the knowledge that 1 in every 10 medical visits will contain diagnostic errors is not exactly comforting to a patient. Moreover, a 2005 survey in the U.S. found that out of 2201 adult survey takers, 1 in 6 had either personally experienced a

misdiagnosis in the past five years, or had experienced one through a friend or relative (Isabel Healthcare, 2006). Additionally, more than half (55%) of survey takers considered misdiagnosis to be their main concern when visiting their family GP, although this percentage was lower (23%) for patients visiting hospitals. It should be noted that although this survey was conducted by the marketing company YouGov, it was commissioned by Isabel Health Care, a company that produces web-based diagnosis assistance systems, which could bias the interpretation. Nonetheless, in conjunction with the Elstein study, one could conclude that diagnostic error is a prevalent problem and that it is of concern to both patients and doctors. The question remains however, what role overconfident decision-making plays in these errors.

Overconfidence as cause of diagnostic error

It is difficult to quantify how common it is for diagnostic errors to be a direct or indirect result of overconfidence, which is partially because detecting diagnostic errors is a challenging task in the first place. Specializations have differing error rates, and there is a variety of different methods that can be used to detect diagnostic error. For example, autopsies and second opinions are both methods that detect error rates, but they can provide very different results (Berner & L. Graber, 2008). Moreover, detection of diagnostic error will differ per researcher because diagnostic error is often defined in varying ways by different researchers (Zwaan & Singh, 2015). Diagnostic errors are also often treated as a dichotomous variable, in which an error is either present or absent. Since the presence of diagnostic error is not always as simple as a yes/no answer, it might be better to detect diagnostic error on a continuous scale rather than as a dichotomy. Moreover, it has been suggested that it might be beneficial to operationalize diagnostic errors differently depending on what illness is being studied. Lastly, it is noteworthy to mention that discussions of diagnostic error usually concern underdiagnosis, while overdiagnosis can be harmful as well, and is just as much an error as underdiagnosis.

What further complicates the detection of diagnostic errors is that even if detection is successful, the next problem is figuring out the exact source of that error. A study by Graber, Franklin and Gordon attempted to do exactly that, in a study that identified 100 cases of diagnostic error and sought out to categorize each in taxonomy of system-related errors, cognitive errors or no-fault errors (Graber, Franklin, & Gordon, 2005). No-fault errors meant highly unusual presentation of symptoms or unwillingness of patients to cooperate, in which the physician was clearly not to be blamed. System-related errors included organizational flaws or

failure of technical equipment. Lastly, cognitive errors included premature closure, faulty context generation and failure to consult for a second opinion. As was discussed in section II of this article, overconfidence is associated with these cognitive biases. The study concluded in the finding that out of the 100 analyzed cases, in 74% of cases cognitive factors played a role.

Section I and II explored how overconfidence impairs people's ability to make decisions, and what variables mediate this impairment. Factors that were mentioned are personality, cognitive biases and motivational aspects. In diagnostic-decision making these same factors are often mentioned

Cognitive biases in diagnostics

As discussed, when a person gains more experience at a certain skill, there is a tendency to shift from System 2 processing to System 1 processing. This same tendency is also found in doctors. After repeatedly coming in contact with familiar illnesses and symptomology, the diagnostic process will require less effort, and will eventually become an automatized process in which physicians recognize and complete familiar patterns (Croskerry & Norman, 2008). As a consequence, physicians become prone to the same system 1 biases that flaw non-medical decision-making. For example, Berner & Graber describe a number of cognitive aspects of overconfidence in doctors. These include failures in properly gathering data and failures to recognize the significance of certain data, as well as failures in metacognition. Some of the biases discussed in section II manifest themselves in ways detrimental to the diagnostic process. For example, the availability bias in doctors will increase the subjective probability of a certain diagnosis if a doctor has recently come in contact with that illness (Croskerry P. , 2003). Confirmation bias will express in a tendency to look for evidence that confirms a diagnosis rather than evidence that disconfirms it. In hindsight bias, knowing the outcome of a past event, such as a treatment or diagnosis, can make doctors overestimate or underestimate the probability of a certain diagnosis (Arkes, Guilmette, Faust, & Hart, 1988).

Section II mentioned the duning-kruger effect, which is the inability of low competence people to evaluate their own skills, which results in overconfidence. This same tendency is found in physicians: residents in training are more confident about their diagnoses compared to faculty physicians, while their performance was lower (Berner & L. Graber, 2008).

We saw in section II that overconfident students stop studying before having fully mastered their study material (Dunlosky & Rawson, 2012). In a similar fashion, overconfident

doctors are prone to premature closing, which is a tendency to stick to one or just a few potential diagnostic hypotheses early on in the process, with a subsequent inability to consider other diagnoses. Moreover, we saw previously that situations of uncertainty often induce overconfidence. It has been found that in the divisions of medicine that deal with more uncertainty, such as family medicine and emergency medicine, the diagnostic error rate is also highest (Croskerry & Norman, 2008)

Personality, beliefs and motivation

In addition to cognitive biases, overconfidence might also stem from personality traits or can be rooted in motivational aspects, just as in non-doctors. For example, Berner & Graber mention a number of attitudinal aspects of overconfidence in medical doctors. These aspects, they say, are reflected by an attitude of arrogance. This is reminscent of the narcissism trait mentioned in section I, which can manifest itself in arrogant behaviours. Berner & Graber argue that an attitude of arrogance leads physicians to think they do not require assistance in the diagnostic process, which leads to a lower utilization of the resources available to them (Berner & Graber, 2008). Moreover, doctors frequently fail to follow guidelines. For example, a study by Steinman et al. (Steinman, Fischer, & Shlipak, 2004) surveyed 139 clinicians on their adherence to guidelines on hypertension treatment. It was found that only 1/3 of surveyed clinicians adhered to medication guidelines. In addition, there was no correlation between perceived adherence and actual adherence to guidelines. It appears that many medical doctors are convinced they follow guidelines where in reality they do not.

Another attitudinal aspect Berner & Graber mention is the finding that decision-support tools are often ignored (Berner & Graber, 2008). Decision support tools are computerized guidelines, alerts or reminders that assist the diagnostic process. It is suspected that physicians partially ignore these guidelines in an effort to maintain autonomous and professional. A desire to uphold a professional appearance and method of working, even when detrimental to proper healthcare, is brought up frequently as a concern in diagnostics. For example, Cassam mentions that physicians can fall for a *professional vice,* in which they become overconfident partially because (over)confidence is valued in the world of medicine (Cassam, 2016). As Croskerry & Norman put it: “Shamans, the progenitors of modern clinicians, would have suffered short careers had they equivocated about their cures” (Croskerry & Norman, 2008). Doctors might

thus be motivated to act confident and autonomously, because such behavior is praised both by patients and the medical community.

As was found in normal populations, overconfidence can be the result of faulty convictions. Similarly, Berner & Graber argue that many doctors are convinced that medical errors are inevitable (Berner & Graber, 2008). Moreover, the prevalence of medical errors appears to be heavily underestimated by physicians. This might be caused by the difficulties of detecting diagnostic errors. Doctors might also not be inclined to report their own mistakes, partially because of the professional vice mentioned earlier. Moreover, a case study that polled doctors and nurses on their attitudes towards incident reporting revealed that doctors express insecurity, anxiety and distrust towards the use of incident data, being afraid of potential legal consequences (Attitudes of Doctors and Nurses Towards Incident Reporting: a qualitive analysis, 2004). Another complication is the fact that the quality of diagnosis is often based on assessing how well the prescribed treatment works, which can be an invalid method of detection (Schiff, 2008). For example, a patient might respond to treatment even though the diagnosis was wrong. The opposite is also possible; some patients do not respond to treatment, which can make a correct diagnosis seem incorrect. This makes it difficult for physicians to track their own diagnostic record.

Use of information resources

Section II addressed studies in which an increase in information resources led to higher confidence but not accuracy. In doctors however, it has been shown that overconfidence leads to a lower utilization of available resource. In an experiment by Meyer et al., physicians were asked to analyze and diagnose four case vignettes, two of which were easy and two of which were difficult (Meyer, Payne, Meeks, Rao, & Singh, 2013). The procedure was divided into four phases, distinguished by the amount of information available to the physician. In the first phase, only a brief complaint of the patient along with a medical history was given. The second phase added a physical examination to this info, whereas the 3rd phase added a general laboratory and imaging. After the 3rd phase the doctors were asked whether they required additional resources. If they answered yes, the 4th and last phase added specialized imaging to the arsenal of information. During the first 3 phases, the physicians were asked to give one to three differential diagnoses of the case at hand, whereas in the last phase they had to decide on a final diagnosis. The accuracy of the diagnoses was measured and the physicians were polled for their confidence

on their diagnosis during each of the stages. The results reveal that physicians were only slightly less confident in difficult cases compared to easy cases, whereas their accuracy on difficult cases was drastically lower. Moreover, overconfident participants were less likely to request additional resources. This is a clear example of more information inflating confidence without increasing accuracy.

Reducing overconfidence in medicine

Given the impact of diagnostic errors on the lives of patients, it is crucial to devise strategies that limit overconfidence in physicians. Overconfidence in physicians has been linked to the cognitive biases discussed earlier, and therefore strategies to reduce overconfidence often also focus on these biases. For example, Croskerry suggests a number of de-biasing techniques. These include education on critical thinking, perspective switching and decontextualizing, but also simply to make doctors aware of the 50+ cognitive and affective biases that flaw human decision-making (Croskerry & Norman, 2008). Although studies on such education show promising results in other populations, only a few studies have addressed such techniques in medicine or related fields. For example, in a study on hindsight bias, a sample of neuropsychologists was given a case history. Subsequently, participants were given three potential diagnoses, and for each diagnosis they had to assign probabilities that it was the correct diagnosis. The sample was split in various conditions, and it was found that hindsight bias was lower when participants were prompted to give a reason why each diagnosis could be possible (Arkes, Guilmette, Faust, & Hart, 1988). The control group in this study also revealed to be the most overconfident. In a similar fashion, it has been suggested that it would be a good to engage in *prospective hindsight,* which means to hypothesize that the current diagnosis is incorrect and to come up with alternatives (Graber, Franklin, & Gordon, 2005).

As mentioned earlier, the duning-kruger effect can be found in physicians as well. Since the effect stems from low competence leading to poor metacognitive abilities, it has been proposed that increasing expertise can also lead to a better assessment of one's skills (Dunning, Johnson, Ehrlinger, & Kruger, 2003). This was subsequently proven in an experiment in which participants solved logic problems and assessed their accuracy. However, the sample of the experiment did not consist of doctors. Presumably, continued medical education and training could be a useful tactic in increasing the metacognitive abilities of doctors. Unfortunately, continued education programs in medicine sometimes show minimal results on actual practice

(Graber, Franklin, & Gordon, 2005). Further experimental research could be dedicated to these continued education programs.

As was shown in section II, a lack of feedback on performance can induce overconfidence. Indeed, Schiff argues that current literature focuses too much on cognitive biases. He argues that increasing the time a doctor has per patient and devising better follow-up strategies to check whether diagnoses were correct would decrease diagnostic error (Schiff, 2008). However, Schiff also mentions that in some cases feedback can be counterproductive. For example, availability bias can actually increase as a result of feedback. As mentioned previously, doctors often have poor insight in the quality of their diagnosis when treatment outcome is used as a measure. A patient can get healthy even though a misdiagnosis was made and vice versa, thus leading to a lack of diagnostic feedback to the physician (Schiff, 2008).

Although feedback has been proven to improve accuracy (Graber, Franklin, & Gordon, 2005), it is unclear whether feedback can decrease overconfidence. In non-medical populations, this seems to be the case. Experimental studies have shown that performance feedback can reduce overconfidence, particularly for difficult items (Stone & Opel, 2000). Future experiments could be dedicated to seeing if performance feedback can lead to lower overconfidence in physicians. As we have seen in section I, people that have an incremental self-theory of intelligence are more open to negative feedback and therefore have a better calibration between their confidence and ability (i.e. lower overconfidence) (Ehrlinger & Mitchumb, 2016). That same study also found that it is possible to manipulate people's self-theory of intelligence, although no study to date has attempted this manipulation on physicians. Although it seems likely that doctors already hold incremental views of intelligence (presumably, the first year of medical school is less challenging than the final year), reminding doctors that even they can always learn more, especially from mistakes, might help in calibrating their confidence.

Costs of reducing overconfidence

Reducing overconfidence in physicians could bring about some unwanted byproducts. For example, a more accurate calibration between accuracy and confidence can lead to doctors spending more time in the diagnostic process and ordering more tests, both of which is costly (Berner & L. Graber, 2008). Reducing overconfidence can also change the dynamics a doctor has with his patients, as well as with other doctors, since lower confidence is not likely to go

unnoticed. For example, a patient might have less faith in a doctor if he/she is less confident, which might lead to more resistance to treatment.

Another potential negative consequence of is that doctors might become increasingly reliant on computerized systems that aid the diagnostic process. As was shown earlier, physicians tend to not use these systems enough. A benefit of this underuse however, is the fact that it requires physicians to think for themselves so that they will not blindly rely on flawed computerized decisions (Van der Sijs, Aarts, Vulto, & Berg, 2005), akin to a person driving their car in a pond by blindly following GPS instructions.

Conclusion section III

The findings on overconfident decision-making appear to translate into the field of medicine. Diagnostic errors caused by overconfidence are a prevalent problem, and they underlie the same cognitive biases that flaw non-medical decision making. In addition, physicians might feel motivated to be overconfident to uphold certain professionalism, or can ignore assistance in the diagnostic process due to arrogance. Strategies to reduce overconfidence in physicians aim at the cognitive biases that underlie human decision-making in normal populations.

Discussion

This narrative review addressed overconfidence, its influence on decision-making and its influence on diagnostic decision-making. It appears that overconfidence as a construct is robust and observable in a variety of contexts. Personality, biology and cognitive aspects combine as potential causal factors of overconfidence. Overconfidence in decision-making has been linked as a factor in some historically poor decisions. In the decision-making process, overconfidence has been linked to the system 1 processes of dual processing theory. These processes include heuristics that lead to a satisfying answer quickly, but are often polluted by numerous biases, such as confirmation bias, representativeness bias and a tendency to not consider alternative explanations. Experiments have found that especially when tasks are difficult or involve uncertainty, people are more likely to rely on System 1 processing, making them vulnerable to overconfidence. In diagnostic reasoning, System 1 processing can lead to diagnostic errors and, in combination with personality factors, can result in non-compliance to guidelines and a lack of differential diagnoses out of overconfidence. Moreover, experiments have found that as doctors obtain more information, their confidence can increase while their accuracy does not. Given the prevalence of diagnostic errors and the impact they have on patients, it is of great importance

that more research will be devoted to combating biases in physicians. Educational techniques that de-bias physicians and make them aware of the scale of the problem of diagnostic errors can potentially reduce overconfidence, but more experimental research should be dedicated to this idea. Continued medical education might enable doctors to increase in metacognitive ability so that they have better insight into their own skills, but this hypothesis warrants more experimental testing. Additionally, performance feedback has shown to be effective in decreasing overconfidence in normal populations. Future experiments could test this same hypothesis in a medical context. Aside from performance feedback, it is important that the diagnostic procedure includes proper follow-up to determine the quality of the diagnosis that was made. Another potential area of research is how decision-support systems influence the calibration of physician's accuracy and their confidence.

This article is limited in numerous ways. Overconfidence appears to be a multifaceted construct in of which the facets are often confounded in research, thus making this article a culprit of that same confounding. Researchers use different definitions of overconfidence and use different methods to detect overconfidence. For example, some studies focus on comparison judgments (over/underplacement) while others detect overconfidence by looking at the number of correctly answered questions with the number of estimated correctly answered questions (over/underestimation). It is therefore questionable whether such studies should be compared with one another and whether they concern the same construct. In physician overconfidence, the literature is subject to this same problem. For example, some of the mentioned studies concern the overconfidence physicians have in a specific diagnostic task, while other studies address how physicians compare themselves to other physicians, often thinking they are better than average and that the problem of diagnostic error is caused by other physicians, and not by themselves. Moreover, some researchers consider overconfidence to be on the same level as other biases that flaw decision-making (availability bias etc.), while other researchers consider overconfidence to be a product of those same biases. This is confusing because the latter perspective will consider overconfidence to a much larger problem (since it includes several biases) than the former perspective.

To further the study of overconfidence, both in regular and medical settings, it is therefore important for future research to clearly operationalize the construct when researching overconfidence, in order to isolate the different underlying facets and determine which of these

should be given more weight in certain contexts. In medicine, better follow-up and feedback measures can increase the detection of diagnostic error and the calibration between a physician's accuracy and confidence.

References

Attitudes of Doctors and Nurses Towards Incident Reporting: a qualitive analysis. (2004). *Medical Journal Australia 181*, 36-39.

Arkes, H. R., Guilmette, T. J., Faust, D., & Hart, K. (1988). Eliminating the Hindsight Bias. *Journal of Applied Psychology 73 (No 2)*, 305-307.

Ayton, P., & McClelland, A. G. (1997). How Real Is Overconfidence? *Journal Of Behavioral Decision Making*, 279-285.

Baumeister, R., Heatherton, T., & Tice, D. (1993). When ego threats lead to self-regulation failure: negative consequences of high self-esteem. *Journal of Personality and Social Psychology*, 141-156.

Berner, E. S., & L. Graber, M. (2008). Overconfidence as a Cause of Diagnostic Error in Medicine. *The American Journal of Medicine*, S2-S23.

Brown, J. D. (2012). Understanding the Better Than. *Personality and Social Psychology Bulletin 38(2)*, 209-219.

Busenitz, L. W., & Barney, J. B. (1997). Differences Between Entrepreneurs and Managers In Large Organizations: Biases and Heuristics in Strategic-Decision Making. *Journal of Business Venturing 12*, 9-30.

Campbell, K. W., Goodie, A. S., & Foster, J. D. (2004). Narcissism, Confidence, and Risk Attitude. *Journal of Behavioural Decision Making 17*, 297-311.

Cassam, Q. (2016). Diagnostic error, overconfidence and self-knowledge. *Palgrave Communications volume 3*, 1-8.

Chambers, J. R., & Windschitl, P. D. (2004). Biases in Social Comparative Judgments: The Role of Nonmotivated Factors in Above-Average and Comparative-Optimism Effects. *Psychological Bulletin Vol. 130*, 813-838.

Chip, H., & Gonzalez, R. (1995). Interaction with Others Increases Decision Confidence but Not Decision Quality: Evidence against Information Collection Views of Interactive Decision Making. *Organizational Behavior and Human Decision Processes*, 305-326.

Craggs, B., & Rashid, A. (2016). The Role of Confirmation Bias in Potentially. *IEEE European Symposium on Security and Privacy.* Saarbrucken: Lancaster University.

Croskerry, P., & Norman, G. (2008). Overconfidence in Clinical Decision Makin. *The American Journal of Medicine 121*, S24-S29.

Croskerry, P., & Norman, G. (2008). Overconfidence in clinical decision making. *American Journal of Medicine*, S24-9.

De Vaus, D. (2002). How To Interpret A Correlation Coefficient. In D. De Vaus, *Analyzing Social Science Data: 50 Key Problems in Data Analysis* (p. 272). London: SAGE Publications Ltd.

Dunlosky, J., & Rawson, K. A. (2012). Overconfidence produces underachievement: Inaccurate self evaluations. *Learning and Instruction 22*, 271-280.

Dunning, D. (2011). The Dunning–Kruger Effect: On Being Ignorant of One's Own Ignorance. *Advances in Experimental Social Psychology Vol 44*, 247-296.

Dunning, D., Johnson, K., Ehrlinger, J., & Kruger, J. (2003). Why People Fail to Recognize Their Own Incompetence. *Current Directions In Psychological Science* , 83-87.

Ehrlinger, J., & Mitchumb, A. L. (2016). Understanding overconfidence: Theories of intelligence, preferential. *Journal of Experimental Social Psychology 63*, 94-100.

Elstein, A. (1995). Clinical reasoning in medicine. *Clinical Reasoning in Health Professions*, 49-59.

Evans, J. S., & Stanovich, K. E. (2013). Dual-Process Theories of Higher Cognition: Advancing The Debate. *Perspectives on Psychological Science 8(3)*, 223-241.

Frankish, K. (2010). Dual‐Process and Dual‐System Theories of Reasoning. *Philosophy Compass 5(10)*, 914-926.

Gordon D. Schiff, M., Omar Hasan, M., Seijeoung Kim, R. P., Richard Abrams, M., & Karen Cosby, M. (2009). Diagnostic Error In Medicine. *Archives Internal Medicine vol 169 (no. 20)*.

Graber, M. L., Franklin, N., & Gordon, R. (2005). Diagnostic Error In Internal Medicine. *Archives Internal Medicine Vol 165* , 1493-1499.

Haruno, M., & Kawato, M. (2006). Different Neural Correlates of Reward Expectation and Reward Expectation. *Journal of Neurophysiology 95*, 948-959.

Harvey, N. (1997). Confidence in Judgment. *Trends in Cognitive Sciences Vol 1, No 2*, 81.

Isabel Healthcare. (2006, 3 20). Misdiagnosis is an Overlooked and Growing Patient Safety Issue and Core Mission of Isabel Healthcare. Retrieved from https://www.isabelhealthcare.com/pdf/USsurveyrelease-Final.pdf

Janis, I. (1991). Group Think. In I. Janis, *A First Look at Communication Theory* (pp. 235 - 246). New York: McGrawhill.

Johnson, D. D., & Fowler, J. H. (2011). The evolution of overconfidence. *Nature Vol 477*, 317-319.

Jonhson, D. D., & Fowler, J. H. (2011). The evolution of overconfidence. *Nature 477*, 317-320.

Jonhson, D., & Levin, S. (2009). The tragedy of cognition: psychological biases. *Current Science 97(11)*, 1596.

Kluger, A. N., & Van Dijk, D. (2010). Feedback, the various tasks of the doctor, and the feedforward alternative. *Medical Education 44*, 1166-1174.

Kuiper, N. A., & MacDonald, M. R. (1982). Self and Other Perception in Mild Depressives . *Social Cognition*, 223-239.

Kurtz, P., Shapcott, K. A., Kaiser, J., Schmiedt, J. T., & Schmid, M. C. (2017). The Infuence of Endogenous and Exogenous Spatial Attention on Decision Confidence. *Scientific Reports 7*, 1-9.

Levy, K. N., Reynoso, J. S., Wasserman, R. H., & Clarkin, J. F. (2007). Narcissistic personality disorder. *Personality disorders: Toward the DSM-V* , 233-277.

Li, K., Szolnoki, A., Cong, R., & Wang, L. (2016). The coevolution of overconfidence and bluffing in the resource competition game. *Scientific Reports 6*.

Meyer, A., Payne, V. L., Meeks, D. W., Rao, R., & Singh, H. (2013). Physicians' Diagnotic Accuracy, Confidence, and Resource Requests. *Journal of Internal Medicine 173(21)*, 1952-1959.

Molenberghs, P., Traitwein, F.-M., Böckler, A., Singer, T., & Kanske, P. (2016). Neural correlates of metacognitive ability and of feeling confident: a large-scale fMRI study. *Social Cognitive and Affective Neuroscience, 2016*, 1942-1951.

Moore, D., & Healy, P. (2008). The trouble with overconfidence. *Psychological Review 115(2)*, 502-517.

Myers, D. G. (2007). How Groups Intensify Decisions. In D. G. Myers, *Exploring Social Psychology* (p. 219). Boston: McGrawHill.

Oskamp, S. (1965). Overconfidence In Case-Study Judgments. *Journal of Consulting Psychology*, 261-265.

Paese, P. W., & Sniezek, J. A. (1991). Influences on the Appropriateness of Confidence in Judgment: Practice, Effort, Information, and Decision-Making. *Organizational Behavior and Humand Decision Processes*, 100-130.

Patricia Cross, K. (1977). Not can, but will college teaching be improved? *New Directions For Higher Education*, 1-15.

Schaefer, P. S., Williams, C. C., Goodie, A. S., & Campbell, W. (2004). Overconfidence and the Big Five. *Journal of Research In Personality Vol. 38, Issue 5*, 473-480.

Scheinkman, J. A., & Xion, W. (2003). Overconfidence and Speculative Bubbles. *Journal of Political Economy Vol 111, No 6*, 1183-1219.

Schiff, G. D. (2008). Minimizing Diagnostic Error, The Importance of Follow-up and Feedback. *The American Journal of Medicine*, S38-S42.

Stankov, L., & Lee, J. (2014). Overconfidence across world regions. *Personality and Individual Differences*, S38.

Steinman, M. A., Fischer, M. A., & Shlipak, M. G. (2004). Clinician Awareness of Adherence to Hypertension Guidelines. *The American Journal of Medicine*, 747-754.

Stone, E. R., & Opel, R. B. (2000). Training to Improve Calibration and Discrimination: The Effects of Performance and Environmental Feedback. *Organizational Behavior and Human Decision Decision Processes*, 282-309.

Svenson, O. (1981). Are We All Less Risky And More Skillful Than Our Fellow Drivers? *Acta Psychologica 47*, 143-148.

Tiedens, L. Z., & Linton, S. (2001). Judgment Under Emotional Certainty and Uncertainty: The Effects of Specific Emotions on Information Processing. *Attitudes and Social Cognition* , 973 - 988.

Tversky, A., & Kahneman, D. (1981). The Framing of Decisions and the Psychology of Choice. *Science vol 211*, 453-458.

Van der Sijs, H., Aarts, J., Vulto, A., & Berg, M. (2005). Overriding of drug safety alerts in computerized physician order entry. *Journal of American Informatics Association*, 138-47.

Wall, M. (2013, February 1). *Columbia Shuttle Disaster's Tough Lesson: Spaceflight Still Dangerous*. Retrieved May 25, 2018, from Space.com: https://www.space.com/19586-shuttle-columbia-disaster-spaceflight-dangerous.html

Yates, F. J., Lee, J.-W., & Shinotsuka, H. (1996). Beliefs about Overconfidence, Including Its Cross-National Variation. *Organizational Behaviour and Human Decision Making Processes*, 138-147.

Zajonc, R. (1980). Feeling and Thinking: Preferences Need No inferences. *American Psychologist 35 (NO. 2)*, 151-175.

Zwaan, L., & Singh, H. (2015). The Challenges In Defining And Measuring Diagnostic Error. *Diagnosis 2(2)*, 97-103.