The impact of physical exercise on unconscious thought processes and decision making.

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Chapter 1: Introduction

“Unconscious Thought Theory (UTT; Dijskterhuis & Nordgren, 2006) represents the latest and possibly last extension of automaticity within cognitive science.”[[1]](#footnote-1)

The concept of automaticity, or automatic (and therefore not conscious) processing, has been discussed in academic literature ever since the 1960s.[[2]](#footnote-2) Recently, the studies of predominantly John Bargh, Ap Dijksterhuis, and their respective co-authors, have contributed significantly to the knowledge of such processes, and accordingly provided a stimulus for further debate and research. Their central claim, that unconscious thought leads to better decisions, greater post-choice satisfaction and increased creativity (at least when dealing with complex issues) has yet to be refuted successfully by its criticizers. Today, the field has evolved beyond the original question whether conscious or unconscious thought always leads to better decisions, and a more nuanced image has become accepted by most.[[3]](#footnote-3) The meta-analysis conducted by Strick et al., which included 92 studies, statistically proved that the unconscious thought effect is a real phenomenon, although it does not always occur.[[4]](#footnote-4)   
 A considerable variety has arose throughout the literature, both in terms of the choice in itself as in the method of distraction to ensure the unconscious thought condition. Preferences to posters, apartments, cars and jobs were tested under various conditions, while to ensure adequate distraction for the unconscious thought conditionpeople were asked to engage in several activities, ranging from solving anagrams, word search puzzles, Remote-Association Tests (RAT) and “*n-*back tasks”. Less mainstream research goals and methods have also been investigated, for example Dijksterhuis et al. have investigated whether the UTT is applicable to predicting soccer matches, and in another study they used Zen meditation as a means of distraction.[[5]](#footnote-5)   
 One specific application of the UTT, that has yet to be investigated, is sports. The benefits of physical exercise on mental health and brain functions are generally accepted, yet somehow the researchers in the field of UTT have not considered physical exercise as a means of distraction.[[6]](#footnote-6) This paper will, however, try to point out that it is not unlikely that unconscious thought processes could be strengthened or accelerated through physical exercise. It will attempt to answer the research question: is physical activity a potential distracter task for future research in the field of unconscious thought processes. This study will therefore search the existing literature, in an attempt to provide a framework for further research on the link between physical exercise, UTT and decision making. In order to provide this framework, it was of vital importance to analyze some associated academic fields, such as the impact of physical exercise or fitness upon cognitive functions and decision making. This work will attempt to bridge the existing gap between these seemingly separate, yet utterly entwined academic research topics.   
 The academic relevance of the following *status quaestionis* thus lies in the framework for further study it will provide. This work will build on the existing general literature dealing with the UTT and other studies that have highlighted the merits of physical exercise (and general fitness) on cognitive performance. It will approach the existing literature in a new fashion and accordingly attempt to point out further research opportunities within the field of UTT.[[7]](#footnote-7) In my opinion, such interaction of UTT with other research areas can only lead to a better understanding of the mechanisms at work during decision making, especially when these other areas look at the decision making process from a different perspective; more specifically from a neurological point of view. Whereas current studies, which have compared (for example) the powerful to the ‘ordinary’ or the ‘hungry’ to the ‘satisfied’, have led to interesting conclusions in the light of UTT and decision making, this study suggests that a comparison between the fit and the unfit, or the exhausted and the rested, could be equally valuable.[[8]](#footnote-8)   
 The suggested topic for further research could, if explored, add yet another reason for companies to stimulate physical exercise amongst their increasingly sedentary workforce. The merits of physical exercise (or general fitness),such as improved health, lower absenteeism and even higher productivity are commonly accepted, yet often not translated into the culture of corporate organizations.[[9]](#footnote-9) Nicolaas Pronk and Thomas Kottke, therefore, suggested that “To counteract the increasingly sedentary nature of work and its unintended consequences on health and productivity, corporations should consider how to integrate physical activity promotion into their overall business planning process.”[[10]](#footnote-10)A solid investigation of the link between UTT and physical exercise, however, is still absent in the current body of literature. Nonetheless, such a study could prove that unconscious thought processes occur during physical activity, which leads to automatic weighting, better decision making, and therefore better on-the-job performance. This study could then add yet another reason for companies to stimulate physical exercise amongst their workforce.   
 There is, however, another way in which a study that investigates the link between sports and unconscious thought processes could be of value. Since physical exercise influences has an impact on the brain (including the part that is responsible for decision making), the assumption might hold that people with different levels of fitness and different preferences regarding physical activity, could react differently to different kinds of stimuli and/or process information in differing ways.[[11]](#footnote-11) Should physical exercise lead to increased access to the unconscious – as, for example, meditation has proved to do – then perhaps this could lead to some interesting (marketing) conclusions for companies such as Nike, Adidas or Puma, which are predominantly oriented towards the sports market.[[12]](#footnote-12)   
 The following chapters will attempt to provide a framework for further research. Chapter two will discuss the theoretical background of this literature review, including the definitions of some key concepts. This chapter will also elaborate briefly on recent debates surrounding the concept of UTT and will thus serve as the theoretical foundation of chapter three. This third chapter specifically addresses the main research question of this paper; i.e., does the available literature indicate future academic opportunities regarding physical exercise and UTT. The literature will be divided into three major areas that will be discussed separately; first the UTT literature with regard to physical exercise will be addressed, then a framework of the existing literature on physical activity and decision making is provided, and finally some recent publications are discussed. Chapter four then answers the initial research question, building upon the three ‘blocks’ of literature discussed in chapter three. Finally, the fifth chapter will wrap up this study by elaborating on the managerial relevance of our findings, whilst also pointing out to the limitations of this research and indicating future research opportunities.

Chapter 2: Definitions and theoretical background

“When making a decision of minor importance, I have always found it advantageous to consider all the pros and cons. In vital matters however . . . the decision should come from the unconscious, from somewhere within ourselves. —Sigmund Freud”[[13]](#footnote-13)

At the beginning of the twentieth century, Freud and Whitehead were the first to question the idea of thinking hard (and thus, consciously) prior to making decisions.[[14]](#footnote-14) By the 1960s, experimental psychology was dominated by behaviorism, which implied that “all (mainly behavioral) responses to the environment were ‘automatic’ in the sense of not requiring any conscious involvement to occur."[[15]](#footnote-15) In 1967, however, Neisser’s ‘seminal treatise on cognitive psychology placed strict theoretical limits on the extent of automatic or environmental control over human thought an behavior’; all subsequent findings until ca. 1990 would remain consistent with Neisser’s formulation.[[16]](#footnote-16) At the end of the millennium, the existence of unconscious thought processes had been proved in several higher mental processes, such as social judgment, social behavior and complex goal pursuits extended over time. In the twenty-first century, Dijksterhuis and Nordgren (2006) introduced a new concept into the domain of unconscious influences; that of judgment and decision making. Even though their initial claims might have been a bit too bold, the impact of their work should not be underestimated; Bargh even mentioned that the introduction of judgment and decision making “might be considered the last bastion of conscious processing.”[[17]](#footnote-17)   
 The evolution of the literature, however, has been less straightforward than abovementioned. The theoretical findings of Dijksterhuis et al. contradicted the very foundations of the existing studies dealing with judgment and decision making, which all perceived these processes to be exclusively conscious activities. The fact that these ‘original’ researchers heavily opposed the idea that unconscious thought processes might play a role in judgment and decision making, is therefore no surprise. The main adversaries of UTT, then, built their case on theoretical, “methodological, as well as empirical (i.e. ‘failure’ to replicate) grounds.”[[18]](#footnote-18) John Bargh’s *Critique of the Critiques*, however, refuted most of the claims of the ‘traditional judgment and decision researchers’. In addition, he indicated that researchers need to be intellectually open to both conscious and unconscious processes, since both play their part in judgment and decision making, and neither is superior in all kinds of cognitive processing.[[19]](#footnote-19) In the same year as Bargh’s study, Strick et al. conducted a meta-analysis that statistically proved the existence of the unconscious thought effect.[[20]](#footnote-20)   
 Throughout this paper, unconscious processes are discussed, yet in order to do so properly, we need to define this concept adequately. The definition that is quoted most often throughout literature is the one composed by Ap Dijksterhuis and Loran Nordgren in 2006, which (in short) stated that “Conscious thought is thought with attention; unconscious thought is thought without attention (or with attention directed elsewhere).”[[21]](#footnote-21) The more extensive version would be: “We define conscious thought as object-relevant or task-relevant cognitive or affective thought processes that occur while the object or task is the focus of one’s conscious attention. […] Unconscious thought refers to object-relevant or task-relevant cognitive or affective thought processes that occur while conscious attention is directed elsewhere.”[[22]](#footnote-22) The key distinguisher between conscious and unconscious thought, according to Dijksterhuis and Nordgren, is *attention*.[[23]](#footnote-23)   
 This attention-oriented definition of unconscious thought, is the foundation of what Dijksterhuis and Nordgren have called *the deliberation-without-attention* effect. Basically, this means that the quality of decisions after conscious thought decreases as the complexity of the decision problem increases, while “the quality of unconscious decisions is always fairly good.” (also see figure 1)[[24]](#footnote-24) This would mean that when you want to buy a car, in which case you have to make a complex decision built on numerous features, people who thought unconsciously were better at weighting the importance differing features, which allowed them to make better decisions than those who thought consciously.[[25]](#footnote-25) This would imply that, when facing a complex decision, one should “leave decisions to the unconscious.”[[26]](#footnote-26) Recently, however, Dijksterhuis has admitted that these strong early claims “were, in retrospect, naïve.”[[27]](#footnote-27) In order to fully grasp the concept of UTT, this explanation of the *deliberation-without-attention* effect was necessary.

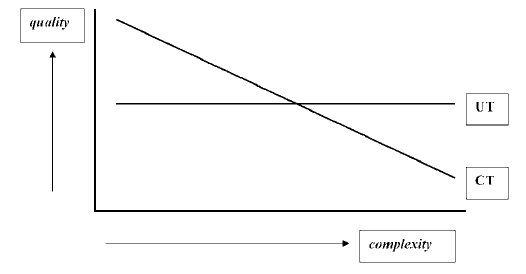


Figure 1. “The relation between the quality and complexity of a decision, as predicted  
by the unconscious-thought theory. For conscious thought (CT), quality varies as   
a function of complexity, whereas for unconscious thought (UT), it does not.”[[28]](#footnote-28)

The Unconscious Thought Theory, as introduced by Dijksterhuis and Nordgren, is built upon six principles. The first principle, called the *Unconscious-Thought Principle* dictates that attention is directed elsewhere (or absent) when unconsciously thinking – as mentioned above. Principle number two is the *Capacity Principle*, which states that unconscious thought has a much higher capacity of consciousness than conscious thought, which is rather limited; people can only focus on a restricted number of attributes, which decreases the quality of their choices.[[29]](#footnote-29) The third principle, called the *Bottom-Up-Versus-Top-Down Principle*, implies that “as a result of unconscious thought, people’s mental representation of a relevant object becomes more polarized and better organized”, which helps people to make better decisions.[[30]](#footnote-30)   
 The *Weighting Principle* was the fourth principle, and, quite intuitively, dictates that thinking consciously often leads to suboptimal weighting, while unconscious processes automatically and properly weight the relative importance of various attributes. The fifth principle is the *Rule Principle*, whichimplies that unconscious thought can only give rough estimates, and is incapable of doing arithmetic, while conscious thought can follow strict rules and is precise. The sixth principle, the *Convergence-Versus-Divergence Principle* is less relevant for this analysis, since it deals with creativity rather than decision making, but it implies that whereas conscious thought is convergent, unconscious thought is divergent.[[31]](#footnote-31) These principles were put to the test throughout a wide range of studies, often conducting multiple experiments that sought to add to the understanding of one specific aspect of unconscious thought processes. The standard experiment starts off by presenting the “participants with a judgment task in which they are to choose the best option from among alternatives varying on several relevant dimensions.”[[32]](#footnote-32) It is important to note that the relevant information in order to come to a proper judgment, as well as the goal (to choose the best alternative), is given to participants consciously. After this “information acquisition stage”, the “critical manipulation” is introduced: participants are divided into three groups: an immediate response group, a conscious deliberation group and an unconscious deliberation group. This last group is distracted – for the same duration as the conscious thought group is considering the alternatives – via a secondary task, such as solving anagrams, word search puzzles, Remote-Association Tests (RAT) or *n*-back tests.[[33]](#footnote-33)   
 The people in this ‘deliberation-without-attention’ condition accordingly answer the questions they were given before they started, and depending on the complexity of the judgment task their answer is expected to be better (or worse) than the answers given by the conscious thought group. According to, UTT the group that thinks unconscious should outperform those who processed consciously whenever the decision is complex enough. As the field evolved – and naïve early claims were refuted – it has become clear that “when making a complex decision, the best strategy would be to consciously encode all of the relevant information and then let the unconscious do the deliberative work.”[[34]](#footnote-34) In order for such ‘unconscious processing’ to occur, diverse distracter tasks are employed throughout literature. A recent meta-analytical study has indicated that the distraction task in itself is a significant moderator of the Unconscious Thought Effect; word search puzzles produced larger effect sizes than *n-*back tasks, while anagrams account for the smallest effects. The effect of physical activity as a distracter task, however, has not yet been investigated.[[35]](#footnote-35) The following chapter will attempt to provide a survey of the existing literature that is (at times indirectly) dealing with these topics.

Chapter 3: Literature review

*3.1: Literature on UTT and physical activity*

“By now, the UT effect has been obtained for many different choices, including hypothetical houses, cars, and computers, posters […], roommates, and even for the predictions of sport games. […] In addition, the UT effect extends to situations whereby people make moral or justice judgments.”[[36]](#footnote-36)

A first important statement, is that until today – to my knowledge – there has been no research whatsoever that has specifically dealt with physical activity and unconscious thought processes. Throughout the available literature dealing with UTT, there is not one study which uses physical activity as a means of distraction for the deliberation-without-attention condition. In fact, it seems very plausible that the only time the word ‘sports’ appeared throughout the UTT literature, was in the study of Dijksterhuis et al. that investigated whether the results of soccer matches could be more adequately predicted after conscious or unconscious thought.[[37]](#footnote-37)   
 A first, indirect, indication of the possible link between physical activity and unconscious thought processes, is to be found in Bos, Dijksterhuis and van Baaren’s study from 2012.[[38]](#footnote-38) In their research paper, which was published in the *Journal of Neuroscience, Psychology, and Economics*, the authors looked specifically at the impact of blood glucose levels upon decision making in conscious and unconscious thought conditions. As the title of their study, ‘Food For Thought? Trust Your Unconscious When Energy Is Low’ suggests, they found out that when glucose levels are low, relying on unconscious thought leads to superior decisions than consciously thinking (also see figure 2).[[39]](#footnote-39) The logical explanation for these findings is that the brain - which “relies on glucose for almost all of its operations” – is less able to consciously reflect, while the unconscious “seems to operate fine with low energy.”[[40]](#footnote-40)

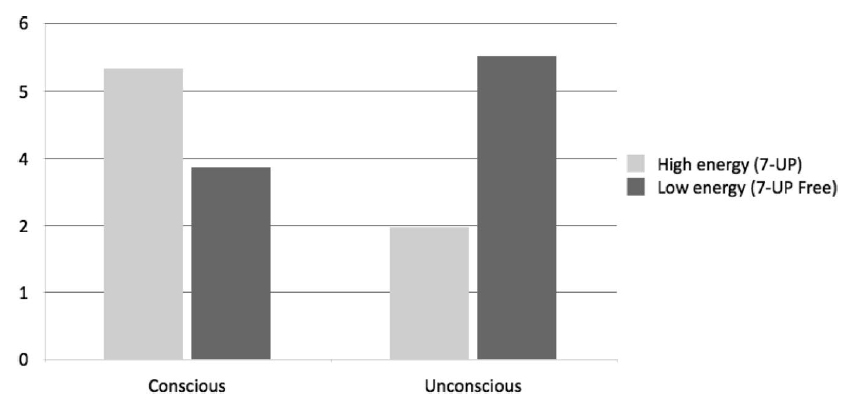


Figure 2. “Performance after conscious and unconscious processing of information  
as a function of high energy (after sugar intake) and low energy (after no sugar intake).  
 Higher scores indicate greater ability to distinguish good from bad options.”[[41]](#footnote-41)

There are, however, some necessary remarks to be made with regard to the results of this study. First, Bos et al. have indicated that there are several shortcomings to their study, the most important one being that the distraction task – watching a movie – might not “fully capture conscious attention. Therefore, conscious processing in the “unconscious processing condition cannot be ruled out completely.”[[42]](#footnote-42) Second, the researchers have briefly attempted to explain the declined decision performance in the unconscious group with high energy. They pointed out that, it had been shown before that “a change of blood glucose level disrupts unconscious processes.”[[43]](#footnote-43) Although, the evidence for this statement was found in diabetes patients, and therefore might not be representational for the entire population.[[44]](#footnote-44) In addition, it is not clear if there is similar disruption when the blood glucose levels drop more gradually, due to exercise, than when they suddenly rise, due to rapid sugar intake in the form of a 7-up. A study in which participants exercise, and accordingly lower their glucose levels more gradually, could therefore lead to a better understanding of the impact of blood glucose level changes on unconscious processes.

*3.2 Decision making and physical activity: meta-analyses*   
Contrary to its absence in the literature on UTT, there is a vast amount of literature which deals specifically with the impact of physical exercise upon cognitive development, decline and, more generally, performance. Meta-analyses focusing on the long term effects, such as these performed by Colcombe and Kramer (2003) and Sofi et al. (2010), to name but a few, all come to the same conclusion: increased physical activity has proved to enhance (elderly) people’s cognitive abilities.[[45]](#footnote-45) These studies are predominantly occupied with the triangular relationship of aging, physical (in)activity and cognitive decline. The long term effects of physical activity on the human brain, however, are no key element to this discourse on unconscious thought processes; but the short term effects definitely are.   
 The amount of literature dealing with the short term effects of ‘acute bouts of exercise’ or ‘acute exercise’ on cognitive performance, also turned out to be quite extensive. The point of departure was 1968; which included two studies that looked at the effect of (respectively) a treadmill run and step-ups on the “performance of simple addition.”[[46]](#footnote-46) A lot of innovation has occurred ever since the works of Gutin and DiGennaro, due to technological novelties and the mainstream evolution of the research domain, although the essence has remained the same: take a population or participants, test their cognitive ability, have them perform a physical(ly exhausting) activity, and then test them again.   
 The problem of the plentitude of studies dealing with exercise and cognitive performance, was overcome thanks to several very helpful meta-analyses. In 1986, Phillip Tomporowski and Kathryn Ellis conducted an early review of the relevant literature, yet they “failed to find empirical support for the notion that exercise has a significant positive influence on cognition.”[[47]](#footnote-47) Eleven years after Tomporowski and Ellis, Etnier et al. published their meta-analysis on physical fitness, exercise and cognitive functioning, in order to provide a more useful conclusion than traditional (narrative) reviews, who merely indicated that results are mixed.[[48]](#footnote-48) Etnier et al. showed that – regardless of exercise intensity – physical exercise improved participants’ simple reaction time, contrary to their choice reaction time, which required more decision making. This result was the opposite of what Etnier and her colleagues were expected to find, which led them “to question the long-held belief that bouts of exercise benefit complex cognitive processes.”[[49]](#footnote-49) The literature review of McMorris and Graydon confirmed this result in 2000; therefore there was consensus regarding the facilitating effect of acute bouts of exercise on speed of responding in simple tasks, yet that it had “little influence on complex-decision-making or problem-solving performance.”[[50]](#footnote-50)   
 In 2003, however, Tomporowski – who in 1986 was unable to find empirical support for the claim that exercise had a significant positive impact on cognition – published another meta-analysis.[[51]](#footnote-51) He analyzed 43 studies to come to his general conclusion, “that acute bouts of exercise selectively facilitate multiple cognitive processes; exercise can, under certain conditions, enhance response speed and response accuracy, and it can facilitate cognitive processes that are central to problem-solving and goal-oriented action.”[[52]](#footnote-52) Tomporowski also indicated that research had shown how even intense anaerobic exercise did not decrease cognitive functions significantly – contrary to what was predicted by the inverted-U hypothesis.[[53]](#footnote-53) Further, he explained that the intensity and duration of exercise are likely to influence how long cognitive function is affected, and that “several theorists predict that an individual’s response to an acute bout of exercise will be enhanced by improving his or her level of physical fitness.”[[54]](#footnote-54)   
 In 2011, Tomporowski, Lambourne and Okumura, reviewed the available literature on the impact of physical exercise on children’s cognitive function.[[55]](#footnote-55) Their main conclusion was that there was a “rapidly growing literature that suggests acute bouts of physical activity facilitate children’s performance on tests that measure attention, memory, rapid decision making and planning.”[[56]](#footnote-56) An important side note proposed in this review, however, was that the brain’s neural networks “are far more mutable than previously believed”, the old vision that these networks could only be modified prior to young adulthood was thus refuted; i.e. it is never too late to start exercising in order to enjoy the cognitive benefits of physical activity.[[57]](#footnote-57)   
 The last meta-analysis discussed here, is the article that was published in the magazine *Brain Research* in 2012, written by Chang, Labban, Gapin and Etnier.[[58]](#footnote-58) Their aim was to provide a more extensive meta-analysis than the existing meta-analytic reviews, including broader inclusion criteria (both children, adults and elderly adults) and more moderators (specific timing of the cognitive test administration and nature of the cognitive task). Even though individual studies continued to provide inconsistent results, the findings of previous meta-analysis allowed the authors to hypothesize that “acute exercise will have a significant small beneficial effect on cognitive task performance after exercise, but will negatively affect cognitive performance during exercise.”[[59]](#footnote-59) One of the secondary moderators indicated by the authors, was ‘specific cognitive tasks’, in which the effects of different kinds of tasks were briefly explained. For executive function tasks, which include verbal fluency, incompatible reaction time, decision making and Stroop interference tasks, “significant positive effects were evident”.[[60]](#footnote-60)   
 In general, the analysis of 79 studies indicated that there is a small positive effect of acute exercise on cognitive performance. This effect can be observed no matter when the cognitive task occurred (during, immediately following or sometime after exercise), which clearly contradicts the initial hypothesis that proposed that acute exercise would negatively affect cognitive performance during exercise.[[61]](#footnote-61) In addition, “positive effects were reported for measures of executive functions” (of which decision making is a part), for both low, moderate and high intensity exercise.[[62]](#footnote-62) The real value of this study, however, is that it provides some clear conclusions regarding the impact of differing moderators on the effect of physical exercise on cognitive performance.   
 The ‘specific-timing’ effect of the cognitive test had already been discussed briefly (it had no impact), yet the authors immediately linked this moderator to another one: exercise intensity. Exercise at very low to moderate levels of intensity proved to be more beneficial immediately after exercise, yet this very low intensity condition turned out to have negative effects on cognitive performance when there was a delay of over one minute. On the other extreme, exercise sessions of very high intensity turned out to maximize the positive effects when there was a delay between the acute bout of exercise and the cognitive task (figure 3). The biggest effects resulted from cognitive tests after a delay of 11 to 20 minutes following very high intensity exercise.[[63]](#footnote-63) As for the exercise duration, they agreed with earlier accounts that indicated that, regardless of testing during or after the exercise session, 20 minutes of exercise is the absolute minimum to witness cognitive benefits.[[64]](#footnote-64) Nevertheless, in exercise sessions of over 20 minutes, fatigue and dehydration start to have an (unidentified) effect – an important path for further research.[[65]](#footnote-65)

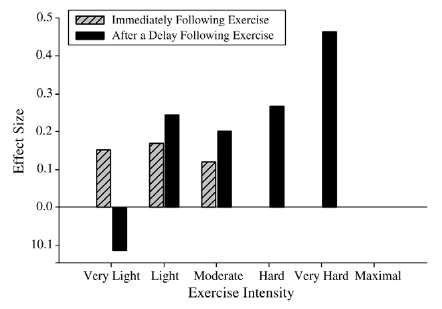


Figure 3. Effect size as a function of paradigm and exercise intensity.[[66]](#footnote-66)

The second combination of moderators analysed in the study of Chang et al., was – again – the ‘specific-timing’ effect of the cognitive test and the initial fitness level. This combination led to two interesting conclusions. The first was that, when participants performed cognitive tests during the acute bout of exercise, there was a significant difference in results between the fit participants and the ‘unfit’. The physically fit participants benefitted from their exercise-condition, while the cognitive performance of participants with low fitness levels was negatively affected. Chang et al., however, also provided an explanation for these contrasting effects: the less fit participants “need more resources when conducting exercise, and therefore have fewer resources available for cognitive performance”, while the physically fit participants were not hampered by this effect.[[67]](#footnote-67) The second conclusion of Chang et al. is all the more surprising given this first conclusion; they indicated that when the cognitive performance of participants was tested following exercise, “positive effects were generally observed for all fitness levels.[[68]](#footnote-68)   
 The authors also argued that the largest effects were observed in studies that included both aerobic and resistance exercise. These results were significantly higher than those observed for mere aerobic exercise. This could occur because the stimulation of “multiple psychological systems yield the biggest gains for cognitive performance.”[[69]](#footnote-69) Chang et al. also nuanced their claims regarding the moderators, and mentioned that their interpretation is limited by third-order causation – an innate limitation in every meta-analysis. [[70]](#footnote-70) Finally, they concluded that their meta-analytical review had explained how exercise benefits performance on cognitive tasks performed while, or after, a bout of exercise. The actual size of the benefit depends on numerous factors, although the results show that fit individuals who exercise for 20 minutes or longer benefit the most.[[71]](#footnote-71)

*3.3 Decision making and physical activity: recent publications*

Recently, Pennington and Hanna have published an article on the ‘Acute Effects of Exercise on Cognitive Performances of Older Adults’.[[72]](#footnote-72) They showed that moderate physical exercise has a strong, immediate, positive and acute effect on cognitive functions in adults over the age of 60.[[73]](#footnote-73) Studies such as this one are not so exceptional in means of methodology, research question or results, yet indicate that the literature on cognitive functions (decision making) and physical exercise is still very diverse. It is this diversity of studies (one could test the relationship between cognitive functions and physical exercise from an abundance of perspectives and specific research questions), that makes the use of meta-analyses unavoidable when attempting to write a literature review.   
 The study performed by Jed Jacobson and Leland Matthaeus, however, is one of those studies that has an unusual, yet for this literature review very interesting, research question.[[74]](#footnote-74) The authors focussed specifically at the type and level of sports in which their participants partook, and the impact of these characteristics on executive functioning. Although they did not submit their research participants to an acute bout of physical exercise, their research question nevertheless contributes significantly to the knowledge regarding general fitness and decision making. They specifically focus on executive functions, which are “highly utilized in [...] goal oriented action under distraction”, and which are divided into “more specific mental capacities such as problem solving, planning, inhibition, and decision making, in order to operationally measure it.”[[75]](#footnote-75)   
 The main idea, that different types of sports could have differing, permanent, effects on executive functioning, seems very plausible. For example: in a sport such as soccer an athlete is always interacting with a constantly changing environment (externally-paced sports), while sports such as swimming are extremely repetitive and monotone (self-paced sports). Their hypotheses, were built upon the idea of athletic superiority. First, they hypothesised that athletes would be superior to non-athletes on all executive function tasks. Second, Jacobson and Matthaeus claimed that externally paced athletes would outperform the self-paced- and non-athletes in both problem solving and decision making accuracy and speed. Lastly, they hypothesised that high skilled athletes would outperform recreational athletes in all executive function tasks.[[76]](#footnote-76)   
 The modified Stroop Test (D-KEFS Color-World Interference Test), the coding and the vocabulary test, however, led to some surprising results. The first hypothesis was the only one that was wholly affirmed by the test results, while the third one did not receive any support. The second hypothesis turned out to be partially correct; the problem-solving aspect received substantial support, yet the decision making aspect of this hypothesis could not be affirmed.[[77]](#footnote-77) This result indicates that, when at rest, externally-paced athletes do not outperform their self-paced ‘colleagues’ in decision making tests, which makes exercise type an irrelevant factor for the decision making ability of athletes at rest. Further research should, however, address whether exercise type remains irrelevant for decision making following an acute bout of physical exercise. Jacobson and Matthaeus also warned for possible ambiguous results, since recent bouts of physical exercise on the athletes’ behalf might lead to disproportionate differences in executive functioning between athletes and non-athletes; although this cannot account for differences between different ‘types’ of athletes.[[78]](#footnote-78)   
 Jacobson and Matthaeus might have failed to find significant support for their hypothesis regarding the impact of sports type on decision making, but their first hypothesis, that athletes would be superior to non-athletes in all executive function tasks, was supported by the data.[[79]](#footnote-79) Another study that looked specifically at athletes, was the analysis of the effect of exercise intensity on decision making performance in experienced an inexperienced soccer players, conducted by Fabio Fontana and his colleagues.[[80]](#footnote-80) Fontana et al. built on earlier studies on this matter by Tenenbaum et al. (1993) and McMorris and Graydon (1996).[[81]](#footnote-81) Tenenbaum and colleagues (who looked at handball-players) concluded that the decision making performance of participants increased significantly during high exercise levels, regardless of the level of expertise of the players. McMorris and Graydon, on the other hand, only found support for faster speed of decision, while there was no effect on the accuracy of decisions.[[82]](#footnote-82) Fontana and colleagues, finally, reached very similar results as McMorris and Graydon, despite several methodological improvements in the experiment.[[83]](#footnote-83)   
 The beneficial effects of physical exercise upon cognitive performance and executive functions, have also been addressed in several neurological studies. In this literature review, for the sake of brevity, the review analysis by Hillman et al. will be discussed to come to the final conclusion.[[84]](#footnote-84) First, Hillman et al. look at the effects of physical activity on cognition in children and young adults. They come to the conclusion that aerobic fitness is positively related to academic achievement, while the opposite is true for body mass index (BMI). Second, the authors show that the same beneficial effect can be perceived in older adults’ cognition; even those with early signs of Alzheimer’s disease. Finally, Hillman and his colleagues turned towards the ‘neuroimaging studies of physical activity in humans’, starting off by explaining the two abovementioned findings from a neurological perspective.[[85]](#footnote-85) However, the most important part of their study, in the light of this literature review, was the paragraph on physical activity and the ‘anterior cingulated cortex.’[[86]](#footnote-86)   
 Research has shown that physical activity improves cognition, with an even larger effect on executive control functions than on other cognitive processes. Following this, “brain structures that mediate executive functions would be expected to show disproportionate changes as a result of participation in physical activity. One such structure is the anterior cingulated cortex (ACC)”.[[87]](#footnote-87) There are two lines of research that specifically look at the effect of physical activity on the ACC: ‘neuroimaging’ and ‘neurophysiological’ research. The findings of both these research lines, suggest “an improvement in task performance in aerobically active individuals through a reduction in conflict-related activation of action monitoring processes.”[[88]](#footnote-88) These conclusions are of paramount importance when one considers that, amongst other cognitive functions, decision making originates in the anterior cingulated cortex. In fact, the link between the anterior cingulated cortex and decision making has been affirmed in several studies.[[89]](#footnote-89)

Chapter 4: Conclusion

The abovementioned literature review offers a framework that allows me to answer the initial research question of this review; is physical activity a potential distracter task for future research in the field of unconscious thought processes? This framework consists of three parts, and each of these parts contributes in a specific manner to the argument that results in the answer of the research question.   
 The first part, which discussed the literature on UTT and physical activity, immediately provides an (indirect) argument for a positive response to the research question. The article ‘Food For Thought? Trust Your Unconscious When Energy Is Low’ suggests that when glucose levels are low, relying on unconscious thought leads to superior decisions than consciously thinking.[[90]](#footnote-90) Given this, while considering that glucose levels drop during physical exercise, it is plausible that the unconscious thought effect increases throughout an acute bout of exercise. If this assumption is accurate, physical exercise could lead to better decision making and improved cognitive performances via unconscious thought processes. The accuracy of this statement can be quite easily tested empirically, using standard empirical experiments from the decision-making literature that deals with physical activity. Participants could be submitted to cognitive tests before, during or after an acute bout of physical exercise. However, there is one important problem that further researchers have to overcome when performing such a study: a sudden change (increase) of blood glucose level disrupts unconscious processes in diabetes patients.[[91]](#footnote-91) The question remains whether this effect is transferable to non-diabetics and if it is also disruptive the other way around (when blood glucose levels drop, for example, during exercise).   
 The second part discussed the meta-analyses dealing with decision making and physical activity, especially those dealing with the short term effects of acute bouts of exercise. These analyses indicated the ambiguous results of empirical studies that looked at the effect of physical activity on decision making. Some meta-analytical reviews failed to find empirical support for the relation between exercise and cognitive performances (Tomporowski and Ellis 1986), while others found selective support (Etnier et al. 1997, McMorris and Graydon 2000), and still others found (small) positive effects on cognitive performance (Tomporowski 2003, Tomporowski et al. 2011, Chang et al. 2012). This latter category, who found empirical support for the relation between exercise and cognitive performance – and more specific: for decision making – represents the latest works and thus illustrates that, although quite recently, some consensus was reached regarding the effects of exercise on cognition. So, if decision making is a process that includes both conscious and unconscious processes, and decision making is also affected by physical exercise, then perhaps a link between physical exercise and unconscious processes might not be so improbable.   
 The latest meta-analysis, conducted by Chang and colleagues in 2012, however, provides some clear conclusions regarding the impact of differing moderators on the effect of physical exercise on cognitive performance. First, with regard to exercise intensity, they showed that the higher the exercise intensity, the longer the beneficial cognitive effects could be observed. They also set out a minimum duration of exercise; 20 minutes of exercise is the absolute minimum to witness cognitive benefits. Second, they indicated that the initial fitness level was also an important moderator; the cognitive performance of ‘physically fit’ participants improved during exercise, while those who are perceived as ‘unfit’ were negatively affected. Nevertheless, “When cognitive performance was assessed following exercise, positive effects were generally observed for all fitness levels.”[[92]](#footnote-92)   
 Chang et al., however, also provided an important nuance of their claims regarding the moderators; they warned for third-order causation, which is a problem in every meta-analysis.[[93]](#footnote-93) Looking at one specific moderator is especially challenging when one is dealing with the very complex processes that are at work during decision making. Should, for example, further research find empirical support for a positive relation between physical exercise and unconscious processes, what would this imply for moderators such as exercise intensity or the initial fitness level? Then the differing effects of physical exercise on cognitive performance during the exercise session (in ‘fit’ and ‘unfit’ participants) might be explained from an entirely different perspective. Whereas the authors have now ascribed this effect to the higher need for resources during exercise of these less fit participants – who therefore had “fewer resources available for cognitive performance”, perhaps this could then be explained in terms of blood glucose levels.[[94]](#footnote-94) The less fit participants’ heart rate would go up faster, lowering their blood glucose levels more quickly, and thus possibly disrupting unconscious processes in this group of participants. Although this last part is highly speculative, evidence for a positive relation between physical exercise and unconscious processes could necessitate some serious reinterpretations of past results.   
 Finally, this study looked at some recent publications that deal with decision making and physical exercise. Jacobson and Matthaeus focused on executive functions, including decision making, in both externally-paced, self-paced and non-athletes. Although they failed to find significant support for their hypothesis regarding the impact of sports type on decision making, their hypothesis that athletes would be superior to non-athletes in all executive function tasks was supported by the data.[[95]](#footnote-95) This implies that, even at rest, athletes outperform non-athletes in executive functions such as decision making, problem solving and planning. Finally, Hillman et al. provided a neurological framework for the effect of physical activity on brain functions. They indicated that neuroimaging and neurophysiological research, that looked at the effect of physical activity on the anterior cingulated cortex, suggests “an improvement in task performance in aerobically fit individuals”.[[96]](#footnote-96) Considering that, amongst other cognitive functions, decision making originates in the anterior cingulated cortex, Hillman and colleagues provided a last argument in favor of further research on the link between physical activity, unconscious thought processes and decision making.   
 Overall, the result of this review is that the research question can be positively answered. First of all, blood glucose levels drop during exercise, and unconscious thought processes are superior when such levels are low. Second, physical exercise has proved to have a positive impact on decision making. Third, even though physically fit individuals gain more quickly from physical activity (during the exercise session), positive effects were observed for all fitness levels after exercising. Lastly, because Hillman and colleagues provided the neurological proof that physical exercise does have an impact on decision making. When all the above is added up, this should suffice to claim that physical activity is a potential distracter task for future research in the field of unconscious thought processes.

Chapter 5: Discussion

Beside the classic limitations of a review (the time needed to read all the relevant papers, the limited space to present your ideas and the extensive amount of literature to be dealt with), this review was predominantly limited by the ambitious research question it attempts to answer. Because the research question required knowledge of two large, and diverse, research domains, it was impossible to deal with the available material in too much detail. To overcome this problem, this review has made extensive use of the available meta-analytical reviews; especially in the domain of physical activity and decision making. The large diversity in this field – both in scope, research question, methods, and outcomes – asked for such an approach, which might appear little original at times, yet is ultimately the only option available to deal with such a broad research question in such a short time.   
 Another limitation was that this review attempts to break new ground, or at least indicate the opportunity for future research to do so. In itself, this might not appear to be a problem, but automatically, when reviewing literature from two domains in order to come to arguments for new research perspectives, ‘neat’ presentations and clear conclusions are not always an option, since the reviewer is actually attempting to create something new out of the existing literature. The reviewer realizes that in such an ambitious setting, with an original research question that is to be legitimated, it is hard to avoid speculation, yet at all times, however, this review has attempted to provide an objective image of the existing literature. Obviously, the aim of this review was to promote one specific topic for further academic research. This topic, the relation between physical exercise, unconscious thought processes and decision making, however, is still quite extensive and diverse. It would be impossible to include all distinct aspects of this topic in one single study, so some more detailed suggestions for further research are provided. First, a study that compares the decision making performance of athletes at rest (conscious thought condition) to athletes during, immediately following and sometime after moderately exercising (unconscious thought condition), could be an interesting study to begin with. Following this, a similar study for non-athletes should occur. This empirical study should be organized like a standard UTT-experiment, except for the distraction condition being a 20 minute run on a treadmill. Preferably participants should follow a prescribed diet prior to coming in for the examination (to avoid all to diverse blood glucose levels) and they should wear a heartrate monitor in order to avoid biased results due to differing levels of fitness.[[97]](#footnote-97) Building on this foundation, then, more complex research questions should be introduced, which take into account moderators such as the initial physical fitness, exercise intensity, nature of the cognitive task, complexity of the cognitive task, athletic expertise, type of athlete, age and specific timing of the cognitive task.   
 If these studies would lead to conclusive evidence in favor of the relation between physical activity, unconscious thought and decision making, then the relevance of these findings would rapidly extend beyond the world of academics. In the competitive world of business, managers would soon try to take advantage of this ‘discovery’, and perhaps this could be the decisive argument for companies to finally install physical exercise programs *en masse.* The reasons for companies to stimulate physical exercise amongst their increasingly sedentary workforce are already plenty, including improved health, lower absenteeism and even higher productivity, yet for some reason corporate culture has – in most cases – yet to embrace physical exercise. Nevertheless, if unconscious thought processes occur during physical activity, and consequently lead to automatic weighting, better decision making, and therefore better on-the-job performance, perhaps physical exercise should then become a mainstream aspect in companies.   
 On a lower level, however, policy changes could also be introduced. Sales managers could exercise once a week with their unit, rather than going on a more conventional lunch. In addition to the teambuilding and health argument, the unconscious thought effect could lead to better on-the-job performance due to automatic weighting. Another possible benefactor could be the Human Resource Manager, who could take physical fitness into account when recruiting from a large pool of applicants. Considering the findings of Jacobson and Matthaeus, logic dictates that, in a hypothetical situation, when a Human Resource Manager has to choose between two candidates with considerably differing fitness levels, and all other things equal, the HR manager will opt for the one that is athletically superior.[[98]](#footnote-98)   
 An entirely different policy application of the relation between physical exercise and the unconscious thought effect, could be related to marketing. Since physical exercise has an impact on the anterior cingulate cortex, which is in part responsible for decision making, the assumption might hold that people with different levels of fitness and differing preferences regarding physical activity, could react differently to several kinds of stimuli and/or process information in diverse ways.[[99]](#footnote-99) Since unconscious thought processes play a significant part in decision making, then from a marketer’s perspective, it could be of vital importance to find a way into this unconscious for companies such as Nike, Adidas or Puma. Thus, when Nike wishes to promote a new product amongst sports enthusiasts, it should design a marketing strategy that is also aimed at concepts such as brand awareness, image and reputation, in order to influence the unconscious thought processes of these amateur athletes.

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19. Ibid. pp. 643; Most recently, Newell and Shanks have attempted to critically evaluate the existing literature on UTT, although their ‘critical review’ turned out to be based on a biased sampling of the literature and flawed reasoning. Dijksterhuis, ‘Newell and Shanks’ and Newell, ‘Unconscious influences on decision making’, pp. 25. The ‘dispute’ between Dijksterhuis on the one hand, and Newell and Shanks on the other, went back a few years, and had also led to mutual criticisms, examples being Dijksterhuis’ ‘Replication crisis or crisis in replication? A reinterpretation of Shanks et al.’, [*http://www.plosone.org/annotation/listThread.action?root=64751*](http://www.plosone.org/annotation/listThread.action?root=64751), (accessed 4th May 2015) and Dijksterhuis, A.J., et al. (2014), ‘The Replication Recipe: What makes for a convincing replication?’, *Journal of Experimental Social Psychology*, 50, pp. 217-224. [↑](#footnote-ref-19)
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32. The options that are provided in the experiment are created in such a way that there is an objectively best one. Bargh, ‘Unconscious Thought Theory and its discontents’, pp. 633. [↑](#footnote-ref-32)
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36. Bos, ‘Food For Thought?’, pp. 125. [↑](#footnote-ref-36)
37. This study also looked at the expertise of the research subjects who predicted the outcome of these games. Experts and novices were compared to one another under both thought conditions. Although this study contributes little to the knowledge on the link between UTT and physical activity, I do suggest that if the research topic proposed in this paper will ever come to be analyzed, researchers should take into account different levels of ‘expertise’ of the research subjects with regard to their athletic capabilities. Dijksterhuis, ‘Predicting Soccer Matches’, pp. 1381-1387. From a sociologist’s perspective, it might also be interesting to note that sports gambling has become so widespread in today’s society, that in some academic domains attention is given to sports gambling prior to actual sports. [↑](#footnote-ref-37)
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39. The researchers manipulated the glucose levels of participants by asking them not to eat or drink anything (except for water) three hours in advance to the study. When the participants arrived, half of them were given 7-Up, a drink containing sugar, and half of them got 7-Up Free, which had the same taste yet did not contain sugar. Bos, ‘Food for Thought?’, pp. 126. [↑](#footnote-ref-39)
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52. Ibid., pp. 317. [↑](#footnote-ref-52)
53. Tomporowski, ‘Effects of acute bouts’, pp. 317. Although sub-maximal anaerobic exercise that is dehydrating does have a negative impact on both information processing and memory functions if it is pursued for a long time. The inverted-U hypothesis is the traditional hypothesis used by sports psychologists to describe the effect of different levels of exercise intensity on cognitive performance. It claims that performance will improve during moderate (aerobic) exercise and decline during maximum (anaerobic) exercise when compared to rest. Graphically, this effect looks like an inverted U. Fontana, F., et al. (2009), ‘Influence of Exercise Intensity on the Decision-Making Performance of Experienced and Inexperienced Soccer Players’, *Journal of Sport and Exercise Psychology*, 31, pp. 136. [↑](#footnote-ref-53)
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66. Ibid., pp. 95. [↑](#footnote-ref-66)
67. Ibid., pp. 96. [↑](#footnote-ref-67)
68. Ibid., pp. 96. [↑](#footnote-ref-68)
69. Ibid., pp. 96. [↑](#footnote-ref-69)
70. Third order causation is the effect that whilst investigating the effects of one moderator, this moderator could also be influenced by another moderator that is not being tested simultaneously. Chang, ‘The effects of acute exercise’, pp. 96. [↑](#footnote-ref-70)
71. Ibid., pp. 96-97. [↑](#footnote-ref-71)
72. Pennington, R. and Hanna, S. (2013), ‘The Acute Effects of Exercise on Cognitive Performances of Older Adults’, *Journal of the Arkansas Academy of Science*, 67, pp. 109-114. [↑](#footnote-ref-72)
73. Ibid., pp. 113. [↑](#footnote-ref-73)
74. Jacobson, J. & Matthaeus, L., ‘Athletics and executive functioning: How athletic participation and sport type correlate with cognitive performance’, *Psychology of Sport and Exercise*, 15, pp. 521-527. [↑](#footnote-ref-74)
75. Jacobson, ‘Athletics and executive functioning’, pp. 521. [↑](#footnote-ref-75)
76. Ibid., pp. 522-523. [↑](#footnote-ref-76)
77. Ibid., pp. 523-525. [↑](#footnote-ref-77)
78. Ibid., pp. 526-527. Jacobson and Matthaeus referred to the following article to found this claim: Etnier, J. & Chang, Y. (2009), ‘The effect of physical activity on executive function: a brief commentary on definitions, measurement issues and the current state of the literature’, *Journal of Sport & Exercise Psychology*, 31, pp. 469-483. [↑](#footnote-ref-78)
79. Jacobson, ‘Athletics and executive functioning’, pp. 523-525. [↑](#footnote-ref-79)
80. Fontana, ‘Influence of Exercise Intensity’, pp. 135-151. [↑](#footnote-ref-80)
81. Tenenbaum, G., et al. (1993), ‘The relationship between cognitive characteristics and decision making’, *Canadian Journal of Applied Psychology*, 18, pp. 48-62; McMorris T. & Graydon, J. (1996), ‘The effects of exercise on the decision-making performance of experienced an inexperienced soccer players’, *Research Quarterly for Exercise and Sport*, 67, pp. 109-114; and McMorris, T. & Graydon, J. (1996), ‘Effects of exercise on soccer decision-making tasks of differing complexities’, *Journal of Human Movement Studies*, 30, pp. 177-193. [↑](#footnote-ref-81)
82. Tomporowski, ‘Effect of acute bouts’, pp. 307. [↑](#footnote-ref-82)
83. Fontana, ‘Influence of Exercise Intensity’, pp. 147. [↑](#footnote-ref-83)
84. Hillman, ‘Be smart’, pp. 64. [↑](#footnote-ref-84)
85. Hillman, ‘Be smart’, pp. 61. [↑](#footnote-ref-85)
86. Ibid., pp. 62. [↑](#footnote-ref-86)
87. Ibid., pp. 80. [↑](#footnote-ref-87)
88. Ibid., pp. 80 [↑](#footnote-ref-88)
89. Two examples are: Kennerly, S., et al. (2006), ‘Optimal decision making and the anterior cingulate cortex’, *Nature Neuroscience*, 9, pp. 940-947; and Bush, G., et al. (2002), ‘Dorsal anterior cingulate cortex: A role in reward-based decision making’, *PNAS*, 99, pp. 523-528. [↑](#footnote-ref-89)
90. Bos, ‘Food for Thought?’, pp. 124-130. [↑](#footnote-ref-90)
91. Ibid., pp. 127. [↑](#footnote-ref-91)
92. Chang, ‘The effects of acute exercise’, pp. 96. [↑](#footnote-ref-92)
93. Ibid., pp. 96. [↑](#footnote-ref-93)
94. Ibid., pp. 96. [↑](#footnote-ref-94)
95. Jacobson, ‘Athletics and executive functioning’, pp. 523-525. [↑](#footnote-ref-95)
96. Hillman, ‘Be smart’, pp. 80. [↑](#footnote-ref-96)
97. Participants should run at a pace dictated by their heart. Possible categories could be low intensity (under 130 beats per minute), moderate intensity (130 to 160 bpm), high intensity (160-180 bmp) and very high intensity (over 180 bpm). Participants should stay in the prescribed categories; should such an experiment be conducted with a standard pace, bias problems would unavoidably occur (running at a pace of 10 km is warmup for some, exercise for others). [↑](#footnote-ref-97)
98. Jacobson, ‘Athletics and executive functioning’, pp. 522-523. [↑](#footnote-ref-98)
99. Hillman, ‘Be smart’, pp. 58-64. [↑](#footnote-ref-99)