BEHAVIORAL RELEVANCE OF CONSCIOUSNESS FOR HUMAN ACTION: EXPLORATIONS WITH THE SIMON TASK PARADIGM

A THESIS SUBMITTED TO

THE GRADUATE SCHOOL OF INFORMATICS OF

THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

SELVİ ELİF GÖK

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

IN

THE DEPARTMENT OF COGNITIVE SCIENCE

SEPTEMBER 2016

BEHAVIORAL RELEVANCE OF CONSCIOUSNESS FOR HUMAN ACTION: EXPLORATIONS WITH THE SIMON TASK PARADIGM

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ABSTRACT

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September 2016, 71 pages

The motivation of this thesis is to investigate whether consciousness has an effect on human behaviors. To this aim an exploratory approach is adopted where an experimental design with two parts is developed. In the first part, participants are first presented objects moving to the left or to the right in accordance with a rule (i.e. familiarization phase), and then transferred to a subsequent two-choice stimulus-response task for stimuli presented at the center of the screen (i.e. Simon phase). Although the stimuli in the Simon phase are presented at the center of the screen, it turns into a Simon task depending on the associations between the rule-relevant features and the movement direction of the objects. Five pilot experiments were carried out in order to devise a viable paradigm in which rule-awareness could be facilitated or hindered.

The results of Experiment 6 suggest that the perceptual and action associations formed in the familiarization phase have a behavioral effect on the subsequent Simon phase whereby the presence of this effect depends on the consciousness of the rule in the familiarization phase (as assessed by the verbal reports of the participants). However, the results of two follow-up experiments (Experiment 7-8) show that declarative knowledge of the rule is insufficient but consciousness of the rule must emerge through the active seeking of the rule and predicting of its outcomes, which enables the formation and transfer of short-term associations between the rule-relevant perceptual features and spatial response codes corresponding to the movement directions.

Keywords: Consciousness, Implicit Knowledge, Action Control, Simon Task, Compatibility Effect

ÖZ

BİLİNCİN İNSAN EYLEMLERİNDE DAVRANIŞSAL ETKİSİ:
SİMON GÖREVİ İLE ARAŞTIRMALAR

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Tez Yöneticisi: Doç. Dr. Annette E. Hohenberger

Eylül 2016, 71 sayfa

Bu tezin amacı, bilincin insan davranışı üzerinde bir etkisi olup olmadığını incelemektir. Bu amaçla, iki kısımlı deneysel bir tasarımın geliştirildiği araştırmacı bir yaklaşım benimsenmiştir. Birinci kısımda katılımcılara ilk olarak bir kurala göre sola veya sağa doğru hareket eden nesneler sunulmuş (tanıtma aşaması) ve ardından katılımcılar, ekranın merkezinde görünen uyarıcılar için iki seçenekli bir uyaran-tepki görevine geçirilmişlerdir (Simon görevi aşaması). Her ne kadar Simon görevi aşamasındaki uyarıcılar ekranın merkezinde sunulduysa da görev, nesnelerin kuralla ilişkili nitelikleri ve hareket yönü arasındaki bağlantılara bağlı olarak bir Simon görevine dönüşmektedir. Tutarlı bir paradigmanın geliştirilebilmesi adına kural farkındalığının kolaylaştırıldığı veya engellendiği beş pilot deney uygulanmıştır.

Deney 6'nın sonuçlarına göre tanıtma aşamasında algı ve eylem arasında oluşan bağlantılar, tanıtma aşamasındaki kuralın bilincinde olunmasına bağlı olarak, ardından gelen Simon aşaması üzerinde davranışsal bir etkiye sahiptir. Öte yandan bu deneyi takip eden iki deneyin sonuçları (Deney 7-8), kuralla ilgili sadece bildirimsel bilginin yetersiz olduğunu, kuralın bilincinin kuralı faal bir biçimde arama ve sonuçlarını tahmin etme yoluyla ortaya çıkması gerektiğini ve bunun da kuralla ilişkili algısal özellikler ve hareket yönlerinin mekansal tepki kodları arasında kısa vadeli bağlantıların oluşturulmasına ve aktarılmasına olanak sağladığını göstermektedir.

Anahtar Sözcükler: Bilinç, Örtük Bilgi, Eylem Kontrolü, Simon Görevi, Bağdaşıklık Etkisi

To My Parents

Yasemin Kumbasar Gök and Emin Gök

ACKNOWLEDGMENTS

I would like to express my appreciation and sincere gratitude to my advisor Dr. Annette Hohenberger not only for her enlightening guidance but also for her patient encouragement and support in all the time of research and writing of this thesis.

I am deeply thankful to Dr. Erdinç Sayan for his inspiring questions and valuable comments on this study, and his support through-out all my undergraduate and graduate studies. I am grateful to my thesis monitoring committee member Dr. Murat Perit Çakır for his valuable comments and suggestions during this study, and Dr. Cem Bozşahin, Dr. Ali Albert Salah, Dr. Murat Ulubay, and Dr. Mehmet Hilmi Demir for their constructive feedback.

Completing this thesis would have been more difficult without the help and support from many friends. I am especially grateful to Emek Yıldırım and Sibel Gülnar for enduring all my spontaneous moods and their patient backing, and Aslı Gök, Songül Gök, Ersin Karaman, Aykut Mert Yakut, Okan Bilge Özdemir and Güner Yazıcıoğlu Akyüz for being there for me in various stages of this process. I would also like to thank Hakan Güler for helping through official procedures.

I greatly appreciate the support of the members of Philosophy Department at Ondokuz Mayıs University, Samsun for making it possible for me to smoothly continue my thesis studies. I especially acknowledge the support and understanding of chair of the department, Dr. Lokman Çilingir.

I am gratefully indebted to my parents Yasemin Kumbasar Gök and Emin Gök for their endless love, trust and support, and taking care of me once more as “himaye.” I am also grateful to my extended family who always makes me feel peaceful with their unconditional love and support.

Lastly, I would like to thank the participants of the behavioural experiments of this study for their time and willingness to attend.

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CHAPTER 1

INTRODUCTION

The motivation of this thesis is to investigate whether consciousness has an effect on human behaviors. This claim seems too trivial from an intuitive perspective that one may even wonder why to bother to investigate it. However, this triviality turns into a puzzle when one tries to understand consciousness on sound conceptual and empirical grounds.

One of the problems in the scientific study of consciousness is that there are very few paradigms available for an empirical investigation of behavioral effects of consciousness in cognitive science (see Atkinson et al., 2000 for a review). Although, there has been a tremendous increase in empirical studies focusing on the difference between conscious and unconscious processes, the majority of these works end with a demonstration of surprising effects of unconscious processing (see Hassin and Sklar, 2014 for a review). This scarcity of paradigms that show the effects of unconsciousness rather than consciousness is understandable, given the novelty of empirical research on consciousness as well as the conceptual challenges described in the literature as detailed in the following section.

The fact that there is no widely accepted theory of consciousness is another major drawback. Also, most of the available theories are not detailed enough to investigate the conditions that enable conscious experience, and the difference it makes in behavior. The unavailability of such a theory of consciousness limits any scientific study to being only preliminary or exploratory in nature. This, in turn, hampers empirical studies of consciousness unlike the more customary or traditional scientific inquiries.

In this study, we embark on such an exploratory approach and investigate the behavioral relevance of consciousness for human actions. To this aim an experimental design is developed in the scope of the present study. This design has two parts. In the first part, participants are expected to acquire knowledge of a rule through the visual presentation of objects following the rule. Here, a combination of color and shape defines in which direction – to the left or to the right – the object will move. In the second part, participants are to act on those objects the required spatial responses to which can be compatible or incompatible with those defined earlier by the rule.

The main goals of the study are to show that knowledge of the rule acquired in the first phase of the experiments the will have a behavioral effect when, later, one is to act on those objects, and the consciousness of the rule has an impact on this behavioural effect. To be more precise, this study shows that the presence or absence of consciousness of the link between visual features and action features in the rule-learning phase, impacts on subjects' behavioral patterns in a subsequent perceptual-motor control task, i.e. the Simon task.

Another important point in the present study is that consciousness of the rule is manipulated in the experimental groups. To provide this controlled manipulation several pilot experiments (Experiments 1-4) are conducted. Although not fully conclusive, the findings of these experiments have implications for designing conditions where one can expect consciousness of knowledge to emerge reliably.

The study is organized in four chapters. The following Chapter 2 consists of four parts where the literature of the relevant domains of cognitive science is reviewed. The first part of this chapter examines both the philosophical arguments and the empirical studies of consciousness. The subsequent parts review the empirical studies in the literature of Implicit Learning, Control, and the Simon task. The experiments conducted in the scope of the study are presented in Chapter 3. Several pilot experiments (Experiment 1-5) through which the final experimental paradigm is developed are reported in the Pilot Experiments part; Experiments 6-8 that reveal the main findings of the study are presented in the subsequent part. In the last chapter, i.e. Chapter 4, a summary of the findings and their discussion are presented with the future works and limitations of the study.

CHAPTER 2

LITERATURE

2.1. Consciousness

Although all humans – as first hand experiencers- have an intuition and non-technical sense of what consciousness is, one peculiar difficulty in the field of consciousness studies is the lack of agreement on what the term refers. On the one hand, consciousness seems to have intimate conceptual and empirical connections with several other phenomena like attention and control. On the other hand, rather than being a unitary concept "the word 'consciousness' connotes a number of different concepts and denotes a number of different phenomena" (Block, 1997, p. 376). In this respect, a clarification on these points is required to set the limits and scope of the present study.

Traditionally consciousness and control are taken as so closely connected that the term 'unconscious control' becomes an "oxymoron" (Hassin, 2005). However, as detailed in Chapter 2.3., recent conceptual and empirical work challenges this identification. What makes attention so related to consciousness, on the other hand, is that one can be conscious of only the attended stimuli. In that sense, attention may be taken as "an agency for bringing a stimulus into conscious awareness" (Baars, 1997; DiGirolamo and Griffin, 2002). Yet, this relation cannot be taken as the identification of the concepts and recent literature reviewed in Bachmann (2011) suggests that depending on the context attention may have effects that both facilitates and counteracts consciousness.

One distinction on different notions of consciousness is between 'species consciousness', 'creature consciousness' and 'state consciousness' (Manson, 2000; Kriegel, 2004; Seth, 2009). Species consciousness refers to when the interest is on the differences between species in the evolutionary line. Creature consciousness can be considered as the overall consciousness status of a particular organism like being awake, in sleep or in coma. As different from creature consciousness, state consciousness is a property of mental states rather than the organism itself. An organism can have unconscious mental states even when awake and fully conscious. It should be noted that, these three notions are not totally independent. For example, a species may be called conscious only if its members satisfy the conditions for creature consciousness (Kriegel, 2004, p.185), or an organism can be considered as conscious only if it has at least one conscious state (McBride, 1999 as cited in Manson 2000). However, the distinction between the three notions seems necessary at least at the current state of the art, because it is possible that function of consciousness from an evolutionary perspective may be different from the function it plays now (Seth, 2009) or "it cannot be that the conscious status of a mental state simply derives from the conscious status of the creature whose mental state it is" since a conscious organism may have both conscious and unconscious states (Manson, 2000, p.408).

Another line of philosophical discussions that is important for the purpose of this study is the one regarding the so-called "kinds" of consciousness. Block (1997) defines four kinds of consciousness, i.e. (1) phenomenal consciousness, (2) access consciousness, (3) monitoring consciousness, and (4) self-consciousness. Phenomenal consciousness comprises the qualitative, subjective aspects of a conscious experience. Access consciousness is defined in terms of the function of a mental state. A state is access-conscious if its content can be directly used in other cognitive faculties. Monitoring consciousness is the reflexive consciousness that acts as a kind of inner "scanner" of thoughts, beliefs, etc. Self-consciousness is having a concept of self and being able to use this concept. It is also worth noting that, although the initial discrimination is between these four kinds, the recent literature generally focuses on the distinction between phenomenal consciousness and access consciousness.

The distinction between the different kinds of consciousness may be viewed from two perspectives. On the one hand, it can be taken as a conceptual clarification of the current state of the art rather than to postulate the independent existence of all kinds (e.g. Block 1997; Lycan 1999; VanGulick, 1995). In such a case the emphasis is on the explanational limitations of the theories of consciousness in that explanation of one kind is not directly derivable from the others. However, it is still possible that the future empirical and conceptual work will gather all or some of these kinds in one coherent concept. On the other hand, it is also claimed that some of these kinds (i.e. phenomenal and access consciousness) have separate neural correlates and it is possible to have one without the other (Block, 2007) or the kinds actually refer to the different problems of consciousness that calls for the addition of some "extra ingredient" that is not available by the current methods of science, to our scientific framework (Chalmers, 2007).

Another related line of thought is whether consciousness is an all-or-none phenomenon. For example, Kouider et al. (2010) propose that what is claimed as different kinds can be a result of grades of consciousness in the sense that when the access to a representation is low it is possible to have a phenomenal feeling without being able to report its content. Also, Cleeremans (2006) offers taking a graded perspective in order to understand the true nature of consciousness. He proposes not only that what are seen as different kinds of consciousness are actually different grades of consciousness where the grade of a representation is determined by its quality, but also that the transition from unconscious to conscious can be viewed as a continuum on the quality of representations.

2.1.1. A General Introduction to Problems and Empirical Studies of Consciousness

Can we study consciousness empirically? This is one of the major problems that one has to face when trying to conduct an empirical study of consciousness. There are several skeptical arguments stating that a scientific explanation of consciousness will probably never be possible due to various reasons, for example its being out of our cognitive limits (McGinn, 1997), or its essential bearing on subjectivity (Nagel, 1997). The question itself and the arguments may lead to some pessimism towards the possibility of any empirical study of consciousness. Yet one may also regard them as caution marks, while not becoming discouraged. In fact, on the positive side, these particular arguments and discussions have (nearly) always led to a conceptual clarification of both consciousness and our intuitions about it. That is, they may not prevent all empirical studies, but rather they may help researchers when they are forming theories, or designing experiments to test hypotheses, or interpreting the result of experiments. However, one should also keep in mind that the relationship between philosophy and science in general, and cognitive science in particular, is not uni-directional. That is, the results of empirical research may also be used to test our intuitions or may have implications related to our philosophical arguments (Scholl, 2007; Nichols, 2004).

One common ground of almost all skeptical attitudes towards the scientific studies of consciousness is related with the above mentioned different kinds of consciousness, i.e. phenomenal and access consciousness where the subjective character of conscious experience is the key to the former and any observable functional character to the latter. For example, McGinn (1997) proposes that to explain unconsciousness we must find the link between the subjective feeling in conscious experiences and their physical basis. However, the way that we know about the subjective character of conscious experience is through introspection, but the physical basis of this experience is investigated through observable facts, i.e. through perception. Accordingly, since we do not have any single method or "cognitive faculty" to investigate these two aspects, the relation between the two and an explanation of consciousness is beyond our cognitive limits. Also, Nagel (1997) grounded his argument on the subjective feeling of, or "what it is like" aspect of conscious experience. He argues that the method of science is objective, and yet all conscious experiences carry a subjective point of view, the view of the organism having that experience, i.e. "what it is like to be" having that experience. Since no objective method grounded on the observable can explain this subjective aspect, consciousness cannot be explained by our current scientific methods.

The difference between phenomenal and access consciousness, which cause the above mentioned pessimistic attitudes towards the scientific study of consciousness, has also its effects on the separation of the problems of consciousness into what has become known as "easy" and "hard" problems (Chalmers, 2007). Easy problems are the ones that are related with the functioning and abilities of the cognitive system and are explainable in terms of functional and neuronal mechanisms. Some examples of these problems are "the ability to discriminate, categorize, and react to environmental stimuli; the integration of information by the cognitive system; the reportability of mental states; the ability of a system to access its own internal states; the focus of attention; the deliberate control of behaviour; the difference between wakefulness and sleep" (Chalmers, 2007, p.225). On the other hand, the hard problem has the phenomenal consciousness in its focus and the problem is the connection between the conscious cognitive functions and the subjective feeling, as Chalmers (2007, p.228) puts it: "Why is the performance of these functions accompanied by experience?" Just at this point, it is important to note that the question itself rests on the conceptual possibility that these functions may occur well without the accompanying experience.

This possibility points to another argument against empirical studies of consciousness that is grounded on the impenetrability of the phenomenological world of the subjects. That is, we can only observe the behavior of the subjects but there is still a possibility that a person (or a person-like creature) behaves just like the others (or human beings), but have a totally different subjective experience or even no subjective experience at all. This is the so-called "zombie" argument (Chalmers, 2007; Dennett 1982). The essential challenge this argument poses against empirical studies is the way that these studies assess the consciousness of a participant. These studies (and also the present one) almost always use verbal reports or some behavioral responses, such as key presses, to assess the consciousness of the subject.

In the light of these considerations one way to rephrase the initially asked question is the following: "Can we study subjective experience that is available only from first-person view with third-person observable data?" Chalmers (2004) proposes that although the subjective experience is not directly explainable from third-person data, there seems a systematic correlation between them. The data of subjective experience can be gathered via verbal reports of subjects where "one does not treat the verbal reports just as third-person data (as a behaviorist might, limiting the datum to the fact that a subject made a certain noise). Rather, one treats the report as a report of first-person data that are available to the subject" (Chalmers, 2004, p. 1117). Accordingly, scientific studies of consciousness must focus on the relations between first-person data and third-person data, and seek for the principles that bridge these two. It is also worth to note that, as a result of the unique subjective character of consciousness as different from other scientific phenomena, the bridging principles will require an "extra ingredient".

Also, according to Dennett (1982) it may really be the case that the subjects in experiments have phenomenal experiences (or no experiences at all) that we do not have any direct access to. So we may not be able to strictly eliminate the zombie argument. However, he proposes our methods still provides us means to make inferences about the experiences of the subjects and this is actually all what we need to start an empirical study in any scientific field. Where these studies will guide us, e.g. whether we will need to postulate nonreducable different aspects or some "extra ingredient," is an empirical question.

2.1.2. Empirical Studies of Consciousness

One of the turning points in the empirical research on consciousness occurred in the 1980s where empirical studies on unconscious processes started to accumulate (Baars, 2003). This accumulation is important because it led the way to treating consciousness as a variable and studying it empirically. That is, it has become possible to conduct empirical studies to investigate the difference between conscious and unconscious processes[1].

There are several empirical studies that focus on consciousness. Being in line with Baars' proposal, these studies mainly concentrate on the difference between conscious and unconscious states, processes, or mental representations. Most of these studies fall under the broader frameworks of studying the difference "between conscious and unconscious streams of stimuli", "between conscious and unconscious elements in memory", "between forms of brain damage that selectively impair conscious process and those that do not", "between wakefulness compared to deep sleep, coma, and anesthesia", and between new and habituated events (Baars, 2003, p. 1).

One of the earliest frameworks that focuses on the difference between conscious and unconscious processing is the subliminal perception that refers to the phenomenon where a participant cannot report to have perceived a stimulus, yet the influence of the stimuli is apparent in some later behavioral tasks. In their 2001 review, Merikle et al. state that there are two different procedures that researchers use to hinder the awareness of stimuli. One can either manipulate the presentation conditions (i.e. visibility) of the stimuli or distract attention away from the stimuli. In the former cases "the stimulus conditions have been systematically degraded until the perceived quality of the stimulus information is so poor that the observers are unaware of the critical stimuli" (Merikle et al., 2001, p.119). In these studies, first a threshold where a participant becomes unaware of the stimuli is set for each participant. That is, if a stimulus is presented below this threshold (sub-threshold condition) the participant cannot report the existence of the stimuli. One of the classical experiments of this kind was conducted by Marcel (1983 as cited in Merikle et al., 2001). The participants in his experiment were to recognize a target word as fast as possible. However, a sub-threshold prime was also presented before each target word. The results showed that the participants were faster at recognizing the target word if the prime was semantically related to the target (e.g. 'nurse' as a prime and 'doctor' as the target) as compared to when it was not related (e.g. 'house').

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[1] It is worth noting that unconscious cognitive processes have had their place in cognitive science just from the beginning. For example, the processes that take place within the Fodorian modules and their intermediate products, or the mechanisims of Chomskian universal grammar are never available to consciousness. However, the unconscious within the domain of current empirical studies is different in the sense that proceses (e.g. learning) or products of these proceses (e.g. knowledge) are potentially available to consciousness, but fail to be under certain constraints. Kihlstrom (1987) categorizes the former as "unconsious in the strict sense of the term", and the latter as "pre-conscious". In this respect, this study and the empirical studies within its scope deal with the unconscious in the latter sense.

Although not immune to the controversies grounded on the assessment methods of consciousness (Holender, 1986), subliminal perception is one of the most studied frameworks of unconscious processing. On the other hand, studies in the broader field of unconsciousness are not limited to perception. Empirical studies and their implications from two such areas, i.e. implicit learning and control, will be detailed in the subsequent chapters. However, it is also worth to briefly mention some other studies that focus on unconscious processing. The results and implications of these studies have important influences on our conceptualization of conscious and unconscious (see Hassin and Sklar 2014 for a review).

One such study has been conducted by Benjamin Libet (Libet 1985) where the focus is on the timing of the decision of a voluntary action and the neural correlates of the action. In this classical study, participants were instructed to move their finger whenever they wanted. However, they were also instructed to pay close attention to the timing of their urge or decision for the movement and report it (by noting the position of a dot on a clock placed in front of them). The results of the study showed that the neural marker of the movement (i.e. readiness potential recorded by EEG) preceded the participants' decision. This result is interpreted as to show that the voluntary action starts before the conscious decision for that action.

Sklar et al. (2012, as cited in Hassin and Sklar 2014) conducted several experiments the results of which suggest that consciousness is not necessary for the integration of abstract units of meaning. For example, in one of their experiments participants were subliminally presented simple arithmetic problems (e.g. 9-3-2=) before a target number where the task of the participants was to identify the target as fast as possible. The results show that participants were faster in trials where the solution of the problem was identical to the target number than where it was different.

There are also some studies that challenge the proposals concerning the relation between consciousness and working memory. Hassin (2005, pp. 205-210) reports the results of a paradigm that was designed to investigate implicit working memory. In one experiment, participants were presented sets of 5 sequentially appearing disks, where they were to respond in accordance with a disk's being empty or full. The appearance of disks in a particular set may either follow a rule, or a broken rule (where all but the fifth disk follow the rule), or no rule at all. The results showed that the participants were faster in rule sets than no rule sets and slowest in broken rule sets. So, Hassin (2005, p.209) states that although participants were not aware of the rule, their performance still showed the traditional features attributed to working memory, i.e. active maintenance, updating, and integration of information.

Unconscious goal pursuit is yet another line of research that questions the long held assumptions about consciousness as reviewed in Custers and Aarts (2010). It is important to note that what are unconscious in this paradigm are not the actions that are taken according to a consciously implemented goal, but rather the implementation of the goals. One framework in this area is the "unrelated studies" design in social psychology. In the 2001 study of Bargh et al. (as cited in Custers and Aarts 2010) participants were to solve two puzzles subsequently where the initial puzzle for one group of participants contained words related to achievement (e.g.

‘win’ or ‘achieve’). The performance of the participants in this group was better than that of the participants, although post-experimental interviews revealed that participants were not aware of the relation between their performances in the two puzzles.

These and abundant studies in the same vein stimulate the discussions and proposals on the limits and respective powers of conscious and unconscious processes. On the one hand, empirical studies are challenged on the face of inadequate assessment of consciousness (e.g. Holender, 1986; Shanks and St.John, 1994; Newell and Shanks, 2014). These critiques propose that the findings of these studies do not show the existence and influence of unconscious cognitive processes but rather conscious processes that are failed to be identified.

On the other hand, some other proposals question the function and causal efficiency of consciousness in the light of these findings. For example, Wegner (2004) claims that the results of the Libet (1985) experiment shows that the participants have a sense of agency even if their conscious decisions can not be the reason of their action due to the timing of participants’ conscious decision of an action and the instantiation of the action. He further investigated this subject by manipulating the sense of agency in several experiments. The results revealed that the participants felt a sense of agency for actions that were not produced by them (Wegner et al., 2004). Furthermore, according to Wegner (2004) the studies of unconscious processes indicate that cognitive functions that were thought to necessitate consciousness can also be performed unconsciously. In the light of these considerations, Wegner (2004) argues that our actions are actually the results of unconscious processes where these processes result both in the execution of the action and a simultaneous feeling of agency. However, this feeling of agency has no effect on the execution of the action. So, he concludes, the long held view that our actions are caused by conscious will is an “illusion”.

This extreme point of Wegner has been criticized on the grounds of not having enough evidence to support his claims (Newell and Shanks, 2014) or on his conceptualization of consciousness and will as “inhabitants” in the brain separate from its unconscious processing (Dennett, 2003). However, the position of Wegner exemplifies the challenge that is raised by the findings that unconscious processes are powerful enough to perform functions that are generally associated with consciousness.

In one sense the area of consciousness studies is faced with the divorce of consciousness from the functions that it was previously associated with. This situation evokes the discussions on the function of consciousness where the proposals include either several other associations of consciousness with again particular functions like error correction or social interaction (Seth, 2009), or integration of high-level functions (Lau and Rosenthal, 2011). Although, these proposals are to be confirmed with empirical studies, the perspective that is proposed by Hassin and Sklar (2014) seems more promising.

Hassin and Sklar (2014, p.307) state that "The argument that nonconscious processes have the ability to perform a function F does not imply that they will always (or even frequently) do so, however. It is a statement about what these processes can do, not about what they actually do." Accordingly, one promising way to study consciousness is to investigate under which conditions particular functions are performed consciously, and whether there will be any difference between conscious and unconscious performance.

2.1.3. Measures of Consciousness

Almost all empirical studies of unconscious processes are challenged by the debates concerning the sensitivity of the measurement of consciousness in the study. These debates in the literature have led to the development of several different measures of consciousness.

Subjective measures refer to any assessment of consciousness that relies on the reports of the participants. On the other hand, in objective measures, any ability to discriminate the stimuli is taken as an evidence of conscious perception. For example, if a participant performs better than chance in a forced-choice task then this is taken as evidence of conscious perception. One of the earliest studies with objective measures is the semantic priming study of Marcel (1983 as cited in Merikle et al. 2001) where the participants cannot detect even the presence or absence of the prime stimuli in a forced-choice decision task.

However, as stated by Merikle et al. (2001, p.124) "the assumption that a failure to discriminate between alternative stimuli indicates an absence of awareness is not necessarily inconsistent with the possibility that correct forced-choice discriminations may also occur even when the perception is not accompanied by an awareness of perceiving."

On the other hand, verbal reports of participants may be subject to subjective biases of the participants. That is, participants may be unwilling to say that they perceive a stimulus (e.g. in subliminal perception paradigms, Merikle et al. 2001), or to state the rule (e.g. in implicit learning paradigms, Tunney and Shanks, 2003) if they are not certain. Additionally, there is also the possibility that participants may have some item-specific conscious knowledge but do not report it since they do not consider it relevant to the task at hand. One way to deal with these problems is to include subjective measures based on confidence ratings.

In the scope of confidence rating measures, participants report their confidence to the accuracy of their answers in a discrimination task. Dienes et al. (1995) propose two such measures of confidence ratings, i.e. the guessing criterion, and the zero-correlation criterion. The guessing criterion concerns discrimination performance of participants when they believe they are guessing. If participants show an above chance performance when in fact they believe they are guessing, then this is taken as an indication of implicit knowledge. However, this criterion is not free from response biases. That is, some participants may tend to report low confidences if they are not certain, and yet some others may tend to report high confidences with little merit. One alternative is to check whether there is a correlation between accuracy and confidence ratings of participants, i.e. the zero-correlation criterion. If participants are conscious of the knowledge that is the basis of their performance in a discrimination task, then they should report high confidence to correct responses and low confidence to incorrect ones. So, a correlation between accuracy and confidence ratings shows that the performance is based on conscious knowledge.

2.1.4. Relation to the Present Study

The terms, ‘consciousness’, ‘awareness’, and even ‘conscious awareness’ are generally used interchangeably throughout the literature. In rare cases, this interchangeability is stated explicitly but without further explanation (e.g. Lau and Rosenthal, 2011). Yet, in most of the studies the interchangeability comes without any further noting. Chalmers (2007), however, suggests making a distinction between the two to emphasize the difference between phenomenal consciousness (i.e. consciousness) and access consciousness (i.e. awareness). Accordingly, the distinction is necessary for not confusing “easy” questions with the “hard” ones.

It is clear that the present study does not focus on the phenomenal properties of consciousness but rather its functional properties, i.e. access consciousness. However, as mentioned earlier the difference between the two kinds can also be considered as a conceptual clarification rather than a proposal for positing two independent types of consciousness that requires also different naming.

Assessment of conscious in the present study is via verbal reports of the participants. If verbal reports are regarded as a way to infer the subjective experience of the participants (as being in line with the proposals of Chalmers, 2004 and Dennett, 1982), any difference between the conscious and unconscious participants can be considered as differences associated with subjective experience. In this sense, this study (and also other studies using subjective measures) can be seen as starting points to answer the “Why is the performance of these functions accompanied by experience?” question by investigating conditions and influences of this accompaniment.

With these considerations, even if one endorses the distinction of the terms ‘consciousness’ and ‘awareness’ as it is proposed by Chalmers, any behavioural difference revealed in the present study will be a difference of consciousness, that is – at least – accompanied by phenomenal consciousness. To be more precise, it is conceptually possible that the results of this study are applicable also to ‘zombies’, but only under the condition that they have their own phenomenal states as expressed in their verbal reports.

However, it is also worth noting that employment of verbal reports as a measure of consciousness, makes the present study vulnerable to the critiques of these measures. As mentioned, one such critique is based on the unwillingness of the participants to state any partial knowledge that they consciously have due to being unsure of it. Most of the studies that are faced with challenge use more complex underlying rules. Yet, since the rule in the present study is simple and participants are also questioned for any partial knowledge, the unwillingness on their side does not seem plausible.

As a last point, the experimental procedure designed in the scope of the present study enables investigating effects of both unconscious and conscious processes. That is, the results of the study have implications with respect to both the effects and limits of unconscious, and the behavioural effect of consciousness.

2.2. Implicit Knowledge and Learning

Implicit knowledge refers to the knowledge that cannot be explicitly reported by the participants but has still an influence on their performance. The so-called "Artificial Grammar Learning" and "Serial Reaction Time" tasks are the two main paradigms that investigate the nature and the extent of implicit knowledge.

The 1967 study of Reber is the classical AGL task. In the first part of the study participants were presented strings of letters and instructed just to memorize them. However, the strings were actually generated via an artificial grammar (See Figure 1 for details). Then, the participants were informed that the strings they had seen were generated by an artificial grammar. Afterwards, they were to judge whether some new strings were also generated by the same grammar or not. Although the participants could not report the rule of the grammar, they showed an above-chance performance in this judging task. This shows that they had implicit knowledge of the grammar even if they could not state it explicitly.

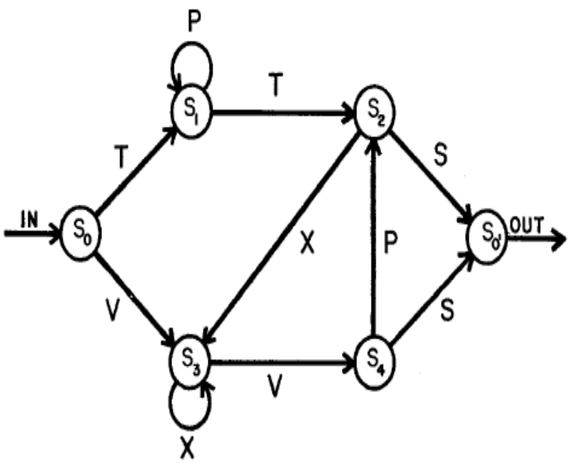

Figure 1 Artificial Grammar used in Reber 1967. An artificial grammar generates strings in accordance with the rule that it implements. For example, the string 'TPTS' can be generated with the shown grammar, where as the string 'TPPT' cannot. The figure is retrieved from the 1967 study of Reber (p. 856).

In the SRT tasks, a target may appear in one of several possible locations and participants were to respond to the location of a target by pressing corresponding keys as fast as possible (Shanks, 2005). What is unknown to participants is that the successive locations of the target are in accordance with a specific sequence. As they proceed with the task, the reaction times of the participants get faster. However, when the sequence is changed there appears an increase in the reaction times. This shows that at least part of the decrease in reaction times before the change of the sequence is due to participants' having acquired the implicit knowledge of the rule.

2.2.1. Transfer of Unconscious Knowledge

One way to investigate the nature of implicit knowledge is to test whether this knowledge is abstract or perceptually bounded. In this scope several studies were conducted in order to find out whether the above chance performance of the participants remained when they were tested in a different domain than the training domain. An initial study of this kind was conducted by Reber (1969) where participants were tested with a grammar that had the identical underlying structure with the training grammar, but had different letters. Despite the above chance performance of the participants in the transfer domain, there was also a decrement in their performance. However, this decrement may be the result of the unnatural mapping between the two domains as suggested by Dienes and Altman (1997). Also, several researchers (e.g. Shanks & St.John, 1994) claim that the above chance performance in a transfer domain does not show that it is the implicit knowledge that is transferred, but rather it can be as a result of fragmentary explicit knowledge that is not detected due to the inadequacy of the consciousness measures.

Dienes and Altman (1997) conducted several experiments investigating whether performance decrement is due to the unnatural mapping and also whether the transfer performance is affected by some explicit knowledge. In their first experiment, they used colors and color words as training and testing domains. Since the mapping between these two is well-developed, any decrement in the performance would show that the acquired knowledge in the training phase was perceptually bounded. The results showed that although participants show an above chance performance both in same and different domains, there is still a decrement in the performance whose magnitude is consistent with the previously reported decrements in the literature. So, the results suggest that, implicit knowledge of the artificial grammars is not completely abstract as claimed by Reber (1969), but rather perceptually bounded to some extent. In their second experiment, Dienes and Altman integrated confidence ratings to test whether explicit knowledge played any role in the transfer performance of the participants. They used colors and letters as two domains (i.e. the mapping between the two domains was not a natural and well-developed one). The results revealed that, although the participants showed no signs of consciousness (as measured both by the zero-correlation criterion and the guessing criterion), they still performed above chance in both domains.

2.2.2. Manipulation of Awareness and Explicit Procedure

Although, implicit learning refers to the phenomena where both learning and the resultant knowledge are unconscious (Kihlstrom et al. 2007), differentiating learning and knowledge is important to investigate the possibly diverse influences of each. Learning is implicit when it takes place without the intention of the learner. On the other hand, explicit learning refers to the cases where the learning is deliberate. However, there is not any necessary connection between the types of learning and consciousness of the acquired knowledge. That is, it is possible both to acquire only implicit knowledge under explicit learning conditions, and to acquire explicit knowledge under implicit learning conditions.

One of the first reports of the effects of explicit learning instructions in AGL tasks is given in Reber 1976 (as cited in Reber et al. 1980), where it was found that the performance of participants who received explicit instruction to search for rules performed worse than participants who received the usual memorizing instruction. To further investigate the role of instruction in AGL tasks, Reber et al. (1980, Experiment 1) conducted an experiment to clarify the relationship between the complexity of the underlying structure of the to-be-learned grammar and the instructions. The results showed that the explicit instructions had a detrimental effect on the performance of the participants in the test phase in complex underlying structures; whereas the effects of the instructions were reversed if the structure was simpler.

In their study Jimenez et al. (2006, Experiment 2) investigated the effect of instructional manipulations in a SRT where one group participants receive the additional instruction to look for the regular patterns while they are responding to the location of the stimuli. The results show that when the training sequence changes, the reaction times increase for both groups, and there is not any significant difference between groups. However, when participants are given a generation task, performances of the groups diverge. In the generation task participants perform either a so-called ‘inclusion’ task where they are to generate series that follow the regularity in the training part, or an ‘exclusion’ task where they are to generate different series. The performance in exclusion is taken as the indication of conscious knowledge since participants need to consciously remember sequences to be able generate different sequences. The performance of the group that does not receive any additional rule seeking instructions does not differ in the two tasks, whereas the other group generates less regularity following series in the exclusion task.

Results of these studies show that implicit knowledge can be acquired even when participants are instructed explicitly search for a rule but fail to do so. However, this instruction has diverse effects on implicit knowledge depending on the complexity of the underlying rule. Also, the Jimenez et al. (2006) study shows that participants in the explicit learning condition can acquire at least partial explicit knowledge as indicated by their superior performance in the exclusion task. This partial knowledge may also be responsible for the superior performance of the explicit learning instruction group for simpler rule in Reber (1980) study.

Another interesting research is conducted by Goujon et al. (2014), where the emergence of explicit knowledge through implicit learning is investigated in a “contextual cuing” paradigm. In this paradigm participants are to identify the location of a target in a display including distractors. Unknown to participants some display configurations are repeated through the experiment and so the position of the target can be predicted from the configuration for these displays. Although, participants cannot recall the repeated displays or fail to generate the target location for them, the decrease in their reaction times for the repeated displays indicates that they implicitly learn them. However, it is shown that for real world scenes participants acquire explicit knowledge of displays (i.e. they can both recall the displays and generate the target location) in addition to decrease in their reaction times (Brockmole and Henderson 2006 as cited in Goujon et al., 2014). In a series of experiments, Goujon et al. (2014) investigate the relation between the explicit knowledge and the reaction time performance. The results show that the decrease in the reaction time precedes the explicit knowledge of the scenes. The researchers conclude that this shows that faster reactions of participants cannot be due to the explicit knowledge, but rather explicit knowledge emerges later than the implicit knowledge.

2.2.3. Relation to the Present Study

As stated in the introduction, the empirical part of the present study consists of two main phases. The first phase of the study is strongly connected to the implicit learning paradigm, especially artificial grammar learning. In this phase participants are expected to learn the underlying rule for the movements of some objects. Yet, different instructional groups are formed to manipulate the consciousness of rule knowledge. It is also worth noting that, as will become clear in the Experimental Studies Chapter, although the design of the main experiment employs the explicit learning instructions, there is also one follow-up study that investigates the case also with implicit learning instructions.

Also, as somehow similar to the design in the transfer experiments knowledge acquired in the first phase of the present experiments is expected to influence performance in a second phase. Although, the findings in the literature are not conclusive on the abstractness and consciousness status of the transferred knowledge, they clearly demonstrate that transfer of knowledge to a nonidentical domain is possible. However, there are two important differences of the present experiments. First, participants are never informed about the relation between the two phases. Also, the second phase of the present experiment requires motor responses, whereas the first phase does not.

2.3. Control

Traditionally, control and consciousness are considered to entertain an intimate relation that even led to the view that there cannot be any control without consciousness of the controlling subject. As Hommel (2007, p.164) puts it "there is some implicit association between consciousness and control that seems so self-evident to many researchers that they do not even bother to explain why they are using it [consciousness, S.E.Gök]." The main reason of this association is the supposed distinction between automatic processes that are assumed to be independent of the intentions of the subjects on the one hand and deliberate control that is in accordance with these intentions on the other. However, Hommel (2007) proposes that this is not an accurate conceptualization of control. For example, in most of the conflict tasks (such as Simon task), where a task-irrelevant feature of an object has an effect on the subjects' behavior, the irrelevant feature has this effect only if subjects are to respond to that particular object that has this feature with that particular response. That is, the interfering response activation is not independent of the current intentions and action goals of the subjects. Accordingly, Hommel (2007, p.166) states that "automatic processes do not represent the opposite of control but, rather, are functional in realizing intended goals."

More recently, Hommel (2013) even claims that consciousness has no causal relation with action control. This claim is grounded in the results of empirical studies, which are in a similar vein with the studies reviewed in Section 2.1.2, that show that most operations of action control, e.g. sense of agency or executive control, can also be performed unconsciously.

2.3.1. Unconscious Conflicts

Eimer and Schlaghecken (2002) conducted a study to examine the influence of subliminal primes in stimulus response compatibility tasks. It was observed that subliminal primes could trigger the activation of corresponding responses. That is, if participants were to respond in accordance with a particular feature of a target (e.g. pressing left for a left pointing arrow), then a subliminal prime that was presented before the target facilitated the response (i.e. resulted in faster reaction times) if it was compatible with the target. However, it was also observed that if the interval between the subliminal prime and the target was long, this effect tended to reverse. That is, participants were faster with incompatible subliminal primes than with compatible ones for longer prime-target intervals. Eimer and Schlaghecken propose that this reversal effect was the result of an inhibition process that "shuts down response tendencies unless their activation level is sustained by facilitatory input from other sources" (2002, p.515). Accordingly, they propose that the reversal of this facilitation should not be observed for suprathreshold primes since the conscious perception of that prime should be sufficient to sustain the activation even for long prime-target intervals. In their experimental settings they used left or right pointing arrows that were presented at the center of the screen for both primes and targets. Participants were instructed to press the key in accordance with the direction of the target. As expected, the participants were faster in incompatible trials than in compatible trials when the primes were subliminally presented. However, they were faster in compatible trials compared to incompatible trials if the primes were suprathreshold.

Heinemann (2011) differentiates three kinds of control processes; i.e. within-trial, between-trials, and sustained control processes. In a trial of a typical conflict task (e.g. Simon task), the conflict triggered by the irrelevant stimulus feature must first be detected and then resolved in accordance with response to be given according to the relevant feature. This control process operating just in the scope of one trial is called within-trial control. Between-trials control refers to the cases where a conflict triggered in one trial affects the performance in the subsequent trial. Post-error slowing, i.e. the increase in reaction times after an error, and the sequential effects (i.e. so-called 'Gratton effect'), i.e. reduced congruency effects after incongruent trials are two examples of between-trials control. Lastly, sustained control refers to cases where a conflict adaptation occurs for a relatively long period of time, e.g. for a block of trials. For example, in the conflict frequency effect the proportion of congruent trials to incongruent trials modulates the size of the congruency effect. The reaction time for incongruent trials and hence the difference between congruent and incongruent trials in a block decreases, if there are more incongruent trials than congruent trials in the block.

One line of study investigates the relation between these different kinds of control and consciousness. These studies particularly focus on whether the different kinds of control elicited by conscious conflicts can also be elicited by unconscious conflicts. To this aim, Heinemann (2011, Experiments 4-6) used a priming paradigm where participants were to respond in accordance with the direction of a target arrow that was preceded by a prime arrow that either pointed to the same (i.e. congruent prime), or different (i.e. incongruent prime) direction. Also, the proportion of congruent to incongruent trials differed for separate blocks (i.e. there were blocks with more incongruent trials, or more congruent trials, or equal numbers of congruent and incongruent trials). As expected, when clearly visible primes were presented, both the sequential effect and conflict frequency effect were apparent as well as the congruency effect. However, when invisible (i.e. heavily masked) primes were presented, neither the sequential nor the conflict frequency effect occurred, but only a congruency effect. The results of this study suggests that the conflict must be consciously perceived for between-trials and sustained control processes to operate, as being different from within-trial control processes. Although this result is consistent with most findings in the literature, van Gaal et al. (2010) report a sequential effect with a similar design also for invisible primes.

2.3.2. Relation to the Present Study

Both the conceptual points proposed by Hommel (2007, 2013) and the experimental studies suggest that control is one of the functions whose association with consciousness does not have apriori justifiable grounds. Nonetheless, this does not directly imply a total independence, but rather emphasizes the importance of empirical studies that focus on their relation.

2.4. Simon Task

2.4.1. General Methodology and Importance

Suppose that you have to press a left key for a stimulus appearing on the right of a screen, and a right key for a stimulus appearing on the left of the screen. You may guess that it would be easier if you pressed a left key for a left appearing stimulus, and vice-versa. This easiness, i.e. better performance on a compatible stimulus-response setting is a vastly studied field in cognitive psychology. The reasons behind this interest may be twofold. Firstly, it deserves attention just for its own sake since determining the manipulations that can change the size or even the direction of the effect may have important practical implications. Yet, the underlying cognitive mechanisms of this effect can reveal important theoretical points concerning the relationship between perception and action more generally (Hommel, 2011).

One early study of this stimulus-response compatibility effect is the 1954 study of Fitts and Deininger (as cited in Proctor, 2011). Participants were to respond to lights that may appear at one of eight locations arranged as a circular array with a stylus that could move to eight locations of again a circular array. The specific locations that participants were instructed to move the stylus for specific light locations formed the stimulus-response mapping. The results showed that the performance of the participants was better when the stimulus-response mapping was compatible. Note that in this and also other conventional stimulus-response compatibility studies the spatial feature (i.e. location) of the stimuli is relevant to the response. That is, participants are instructed to respond in accordance with the spatial feature of the stimulus.

In 1967 Simon and Rudell conducted a different kind of stimulus-response compatibility study. They were investigating the effect of irrelevant features on subjects' performance. In the initial study the words 'left' or 'right' were presented as auditory stimuli either to the left or right ear of the participants. Participants were to press left or right keys in accordance with the meaning of the words disregarding the ear position. The results showed that the performance was better when the word meaning and the ear position correspond. However, this is not a proper Simon task in the conventional sense yet since the irrelevant stimulus feature (left or right ear) is related to the relevant stimulus feature (meaning of 'left' and 'right') (Proctor, 2011).

The first real Simon task was the one by Simon and Small (1969) where subjects had respond with left and right key presses to tones of different height presented to their left and right ear. According to the rule, they had, e.g., to press right for the high tone and left for the low tone. Compatible trials were those where the high tone was presented to the right ear and the low tone to the left ear; incompatible trials were those where the high tome was presented to the left ear and the low tone to the right ear. Nowadays, the Simon task is typically conducted in the visual modality.

What is now considered as classical Simon task (see Figure 2) is the one where participants are to press in accordance with the color of a stimulus under a specific color-response mapping, e.g. the left key for blue objects and right key for red objects. A stimulus may appear either on the right or on the left of a screen. The trials where the location of the stimulus corresponds with the response are called 'congruent trials'. They are called 'incongruent trials' if location of the stimulus and response do not correspond. The term 'Simon effect' refers to the mean reaction time difference between congruent and incongruent trials.

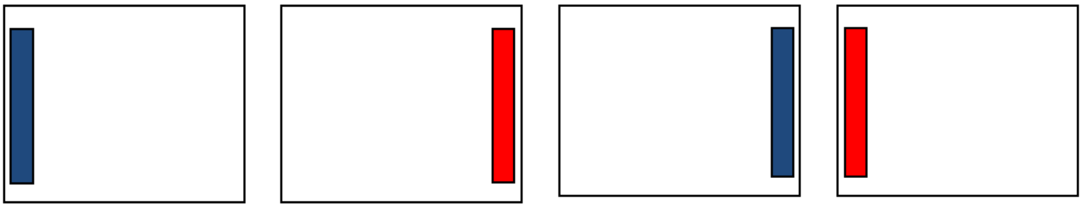

Figure 2 Example of Simon task congruent and incongruent trials. Congruent and Incongruent trials under the instructions "press left key for blue objects and press right key for red object."

This effect cannot be attributed directly to anatomical or hemispheric factors (i.e. right visual field and right hand are both represented in the left hemisphere whereas the left visual field and left hand are both represented in the right) since the effect also occurs when the stimuli and responses are arranged in the vertical dimension, or responses are given uni-manually or bi-manually but with crossed hands (Proctor, 2011). As an initial explanation of this effect Simon (1990 as cited in Proctor 2011, p. 184) states that "There seems to be a strong stereotypical tendency to respond initially to the directional component of a stimulus rather than to its symbolic content".

Hommel (2011, p.190) proposes that one important point that distinguishes the Simon task from other stimulus-response compatibility tasks is that it is "a particularly pure measure of the impact of a task-irrelevant stimulus feature on response conflict." That is, the arbitrary mapping of response and task-relevant stimuli indicates that the conflict in the Simon task arises between the responses induced by task-relevant and –irrelevant features of the stimuli.

Contemporary accounts of the Simon effect usually refer to the interference between two response activation pathways. One pathway is activated through task-induced short-term associations, i.e., the rule given to participants. The other pathway is activated automatically through long-term associations as a result of the spatial features of the stimuli (Proctor, 2011). It is also important to note that, the effect is also observed for the direction of the movement of a stimulus or even with respect to the directional component of the context in which the stimuli appear. So, the irrelevant spatial feature that affects the response is not restricted to just the location of the stimuli but can be a more abstract spatial feature (Hommel, 2011).

2.4.2. Transfer Effects in the Simon Paradigm

One important effect that is investigated in the Simon paradigm is the so-called transfer effect. The transfer effect occurs when participants first practice location-relevant incompatible trials and then are transferred to a Simon task with the same stimuli (Vu, 2011). In the former practice trials, i.e. location-relevant incompatible trials, the participants are asked to press the key that is opposite to the location of the stimulus. In such a setup, participants show a reverse Simon effect (i.e. faster reaction times for incongruent Simon trials) in the subsequent Simon task, regardless of the delay between practice and Simon task. Vu (2011) proposes a two-fold reason of this transfer. First, it may be the case that during location-relevant incompatible trials participants explicitly learn the rule and use a "response to opposite strategy". Then they transfer this knowledge to the location-irrelevant Simon task. The second possibility is that unintentional, yet strong associations are formed between the location of the stimulus and opposite keys as a result of the spatial incompatibility in the initial task. He then proposes that if the transfer effect is the result of explicit learning rather than implicit associations, then it will only occur if the participants can report the incompatible mapping rule. The practice part of the Vu 2011 experiment consists of red and green circles that appear on the left or right of the screen and the participants are to press keys in accordance with the color of the stimuli. However, unlike a conventional Simon task (where the ratio of congruent to incongruent trials is 50%), 75% of the trials are incongruent. Then participants are transferred to a usual Simon task. There is also a control group for whom the stimuli of the practice session are presented in the center of the screen. The knowledge of the participants on the incompatible mapping of the practice trial is assessed via a post-experimental interview. That is, they are asked whether they noticed any patterns or relationship in the two parts of the experiment. In the first experiment, none of the participants becomes aware of the rule. The results show a reverse Simon effect in the practice session (which is expected since 75% of the session consists of incongruent trials). However, all participants show a normal Simon effect in the Simon task. Also, there is no significant difference in the Simon effect between the control group and the experimental group, although the Simon effect of the experimental group is numerically smaller. Since none of the participants in this experiment became aware of the incompatibility, Vu (2011, Experiment 2) conducted another one where the practice session consisted only of incongruent trials. He proposed that if implicit associations are sufficient for a transfer effect, then there should be a transfer effect for all participants. Yet, if explicit knowledge of the incompatible mapping is required, then we should observe the transfer effect only in the participants who become aware of the incompatibility and can verbally report it. Around half of the participants (28 out of 60) could report the incompatible mapping in the post-experimental interviews. The results of the experiment showed a significant reverse Simon effect for these participants. On the other hand, participants who could not report the mapping show an insignificant Simon effect. Vu (2011, p.222) states:"The results of this experiment suggest that a small part of the transfer effect can be attributed to the residual activation of repeatedly executing the noncorresponding response that can occur without awareness, but the largest part of the transfer effect is due to participants' being able to explicitly represent the S-R mapping in the practice session".

Another frame of study that examines the role of task-defined short-term associations in the Simon tasks is mixing location-relevant incompatible trials with location-irrelevant trials (Proctor et al., 2000). In location-relevant incompatible trials, participants are to respond to the location of a stimulus with an incompatible key press (e.g. pressing right for a white circle presented at the left, and vice-versa). In the location-irrelevant trials, on the other hand, they are to press in accordance with the color of the stimulus regardless of its location (i.e. Simon task). It is found that such a mixing results in a reversal of the Simon effect. That is, participants are faster in incongruent trials than in congruent trials of the Simon task. This effect is attributed to the short-term associations that are formed through location-relevant trials. The effect may also show up when participants are to attend the Simon task again even after some time interval (days, or weeks). Proctor et al. designed some follow-up experiments to answer a more specific question concerning the nature of these short-term associations. They investigated whether the effect of these associations was specific to the stimulus mode or whether they were formed on a more conceptual level. To this end, they used arrows (pointing towards left or right) and location words (i.e. 'LEFT' and 'RIGHT'), as well as circles. When the same mode of stimuli was presented in both location-relevant incompatible trials and location-irrelevant trials, a reverse Simon effect occurred as expected. However, when the modes of stimuli were different for the two types of trials, there was either no effect or a positive one. Accordingly, Proctor et al. conclude that the results indicate that the effects of short-term associations are mode-specific rather than conceptual.

In the studies described above, short-term associations stemming from an initial task that are considered to have an effect on the later Simon tasks are formed between features of stimuli and the responses. Pellicano et al. (2008), on the other hand, conducted a study to investigate whether short-term associations that are formed between features of stimuli have a similar effect. There are again two parts of the study: In the first part, which is called "associative-learning task", one stimulus of two different colors is presented regularly at one side of the screen in each trial (e.g. green stimuli are presented on the left and blue stimuli are presented on the right). Participants are not instructed about this regularity and they are to count the number of stimuli for each color. In the second part of the experiment, stimuli are presented at the center of the screen and participants are to press a key in accordance with the color of those stimuli. This second part has a corresponding stimulus-response mapping for half of the participants, whereas a non-corresponding mapping for the other half. That is, in the corresponding mapping group if the green (blue) stimuli appear on the left (right) of the screen in the first part (i.e. associative-learning task), then in the second part participants are to press left (right) key for green (blue) stimuli. On the other hand, in the non-corresponding mapping group if the green (blue) stimuli appear on the left (right) of the screen in the first part (i.e. associative-learning task), then in the second part participants are to press right (left) key for green (blue) stimuli. As similar to the Simon effect, it is expected that participants in the corresponding mapping group will show better performance (i.e. faster responses and lower error) than those in the non-corresponding mapping group. The results showed that this was indeed the case for the first 5 trials of the second part. However, for the rest of the trials the reaction time and error data showed different patterns. That is, participants in the corresponding group had faster reaction times but higher error rates than the participants in the non-corresponding group. Pellicano et al. (2008) concluded that the correspondence effect in the first 5 trials was a result of short-term associations that were formed in the first part. However, later, participants in the non-corresponding group adopted a more conservative response strategy than in the corresponding group.

Another recent important line of study investigates whether transfer effects can be prompted only by instructions. In the study of Liefooghe et al. (2012), participants received the instructions for two different tasks (called as “inducer” and “diagnostic” tasks) at the beginning of the experiment, but performed the “diagnostic” task before the “inducer task.” For the “diagnostic” task participants were to respond with left and right keys in accordance with the identity of the stimuli (e.g. left for N, and right for Q), and were instructed to respond to the orientation of the same stimuli for the “inducer task” (e.g. left for upright, and right for italic). Although they performed the “diagnostic” task before the “inducer” task, the results revealed a congruency effect where responses compatible with the “inducer” task (i.e. left response to an upright N) are faster, than an incompatible one (i.e. left response to an italic N). This finding shows that short-term associations formed merely on the basis of instructions have influence on the performance. Furthermore, this effect was present even if the responses were to be made in different modalities (e.g. same keys, different keys or vocal responses). However, in the same study Liefooghe et al. (2012, Experiment 2) also showed that the influence of the “inducer” task on the “diagnostic” task depended on whether or not participants were prepared to act. That is, if participants received instructions just to recall or recognition for the “inducer” task there does not appear a congruency effect. This result underlines that a strong action-relevance must be present in order for the instructions to induce a congruency effect.

2.4.3. Relation to the Present Study

The behavioral effect that is expected to occur in the second phase of the experimental studies is a Simon effect. However, as different from the traditional Simon task, the stimuli in this phase are presented at the center of the screen. Yet, as will be detailed in Experimental Studies Chapter, the responses in this second phase can be compatible or incompatible with the rule in the first phase. Accordingly, any transfer that takes place between these two phases is expected to be revealed as a Simon effect.

CHAPTER 3

EXPERIMENTAL STUDIES

The reviewed literature suggests that previously formed short-term associations may have an influence on a later Simon task. A related study was conducted by Eren and Hohenberger (2009). The first part of the study is the so-called "familiarization phase" where participants were to watch a slide show. In each slide a moving object hit another one situated on top of a pyramid whereupon the latter fell either to the left or the right depending on the color of the first object. The participants were never instructed about the regularity between the color of the first objects and the direction of the falling object. Though, it was expected that short-term associations between color and direction would be formed. Then the participants were transferred to the second phase of the experiment. In the second phase, the participants were to press left or right keys in accordance with the color of the stimuli. In the second phase, each stimulus was presented at the center of the screen. If the short-term associations between color of the object and direction had been formed in the familiarization phase, the second phase should be a Simon task for the participants. The knowledge of the participants of the rule (i.e. the regularity between color and movement direction) was assessed via a post-experimental interview. The results of the study did not show any Simon effect when the participants were considered as a single sample, overall. However, the data was also analyzed with "awareness of the rule" being a (ex-post facto) between-subjects variable. The results showed a significant group and congruency interaction where participants who were unaware of the rule tended to show a normal Simon effect, and participants who were aware of the rule tended to show a reverse Simon effect. Yet, when analyzed separately there was no significant effect for either group.

The general procedure adopted in the present study is similar to the study of Eren and Hohenberger (2009). However, several pilot experiments (Experiments 1-5) led to a number of changes until the final design that is shown in Figure 3, That is, participants are first presented objects moving in accordance with a rule (i.e. familiarization phase), and then transferred to a subsequent stimulus-response task for stimuli presented at the center of the screen (i.e. Simon phase). Although the stimuli in the Simon phase are presented at the center of the screen, a trial can be considered as congruent or incongruent in the sense that the response required for that trial can be compatible or incompatible with the rule in the familiarization phase. For example, in the familiarization phase of the Experiments 6-8, objects move to the left or to right depending on the color and shape features of the objects (i.e. all green triangles moves to the left, whereas all blue squares moves to the right) and the response rule in the Simon phase depends on the inside pattern of the objects (i.e. press left for spiral inside patterns and right for dotted inside pattern). So, a response in the Simon phase that is the same as the movement direction of the object in the familiarization phase (e.g. a left response for a green triangle with spiral inside pattern) is compatible with the familiarization rule, whereas a response that is different from the movement direction (e.g. a right response for a green triangle with dotted inside pattern) is incompatible. If short-term associations between rule-relevant features and movement direction are formed in the familiarization phase, they will influence the performance of the participants in the Simon phase due to the response – familiarization rule compatibility. Accordingly, a Simon effect should occur even if the objects are presented in the center of the screen.

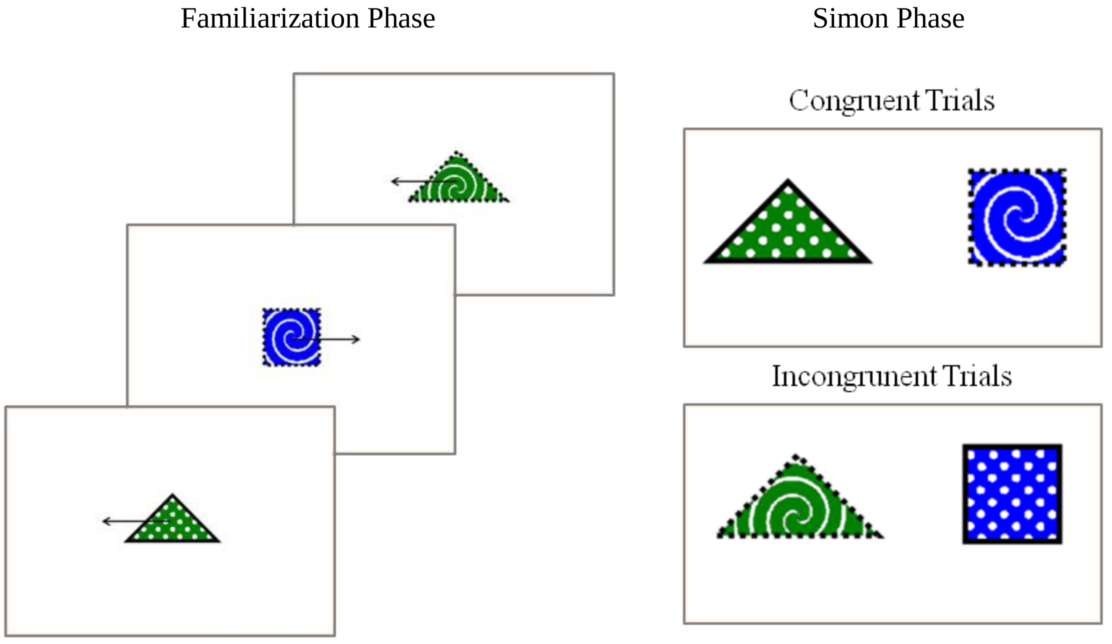

Figure 3 Experimental Stimuli.
In the familiarization phase, green triangles move to the left, whereas blue squares move to the right.
The right panel shows the examples of "congruent" and "incongruent" trials in the Simon phase when participants are to press left key for dotted patterns and right key for spiral patterns. It is important to note that location (left-right) is not a feature of the objects in this phase at all. It only becomes a feature if participants have formed associations between the visual features of the objects and the movement direction (left-right) in the initial familiarization phase.

This study has the following general hypotheses:

H1: The short-term associations that are to be formed during the familiarization phase will influence the performance in the subsequent Simon phase.

H2: The Simon effect will be different for participants who become aware of the rule and those who do not.

In Experiments 1-6 these two hypotheses will be tested. In Experiments 7-8 further hypotheses will be tested, which will be indicated for each experiment, respectively.

3.1. Pilot Experiments

A short-coming of this initial study (and also the study of Vu, 2011) was that the awareness of the participants of the rule was not manipulated in the experiment itself but only assessed afterwards in a post-experimental interview. We hypothesized that a manipulation that can group participants into “aware” and “unaware” conditions in a more controlled way may lead to more robust results. Accordingly, Experiments 1-4 are conducted to construct a design that enables a controlled manipulation of awareness of the rule. Also, although a controlled manipulation of awareness is provided in Experiment 4, since the results of Experiment 5 points an unexpected influence of stimuli in the Simon phase, the stimuli in this phase are changed.

The particular changes of procedure that take place through the pilot experiments are as follows:

In Experiment 1, different experimental groups are formed with respect to the different instruction they receive in the familiarization phase. However, this difference failed to provide the manipulation of awareness where most of the participants in all groups become aware of the rule.

In Experiment 2, experimental groups differ with respect to the number of cycles that are presented in the familiarization phase. However, results imply that participants in the group that are unaware of the rule also presented too few cycles to have any effect.

In Experiment 3, the instructional manipulations in Experiment 1 are employed but the number of rule relevant features is increased to hinder all participants become aware of the rule. Yet, with the increase in the rule relevant features hinders the extraction of the rule so severely that most of the participants become unaware of the rule.

In Experiment 4, same instructional manipulations and rule in Experiment 3 are employed, but the participants are informed about the existence of the rule and asked to predict it through the familiarization phase. Although the controlled manipulation of awareness is achieved in this experiment, Experiment 5 indicates interference between response dimensions in Simon phase and inside patterns of the stimuli.

3.1.1. Experiment 1

Attention may play a facilitatory or inhibitory role in the emergence of consciousness. Accordingly, groups in the present experiment were directed either to the rule-relevant feature (color) or a rule-irrelevant feature (border) in the familiarization phase. To this aim, the groups were instructed to name aloud the particular feature. That is, one group was to say the color of the critical object aloud upon seeing it; the other was instructed to say the border of the object aloud; the last group, i.e. the control-group, was just asked to watch the slide show without saying anything. We expected that the color-naming group would become aware of the regularity since they were directed to the relevant feature; however, the border-naming group would not become aware since they were distracted away from the relevant feature.

Participants

36 students (21 male, 15 female, age range: 23-31 years) of Middle East Technical University participated in the experiment. They reported to have normal or corrected-to-normal vision.

Apparatus[2]

The experiment is conducted by on a 36x47x4 cm Dell PC, running Microsoft Windows XP. The stimuli are presented on the 15.4' screen of the computer. The familiarization phase is presented *via* the Microsoft Power Point software. E-Prime 1.2 is used to design and conduct the Simon phase. This software also randomizes the order of the stimuli and records the reaction times.

Procedure and the stimuli

The experiment was conducted on a 36x47x4 cm Dell PC, running Microsoft Windows XP. The stimuli were presented on the 15.4' screen of the computer. The familiarization phase was presented via the Microsoft Power Point software. E-Prime 1.2 was used to design and conduct the Simon phase. This software also randomizes the order of the stimuli and records the reaction times.

Familiarization Phase:

In the familiarization phase participants were presented a slide show. In each slide there were three objects: a stable light blue pyramid that was centered at the bottom of the screen, a creamy colored circular object that was situated on the top of the pyramid, and the critical object that first appeared above the creamy object. Only the critical object differed in the slides. There was a total number of 12 such objects that were of a unique combination of color (blue or green), shape (square or rectangle), inside pattern (vertical, horizontal or diagonal), and border (straight or dashed).

For each slide, the critical object first appeared at the top of the screen. It then begins to fall towards the creamy circular object on the top of the pyramid, and stopped once it hit it. Then the latter fell to the left if the color of the critical object was green, and to the right if it was blue. (Figure 4 shows snapshots from the familiarization phase). A fixation slide, i.e. a slide only with a fixation cross at the initial place of the critical object, is presented between all object slides.

A cycle in the slide show was completed when all 12 critical objects had been presented (i.e. a cycle consists of 24 slides with 12 object and 12 fixation slides). 3 cycles were presented in the familiarization phase.

[2] The same apparatus is used for all experiments.

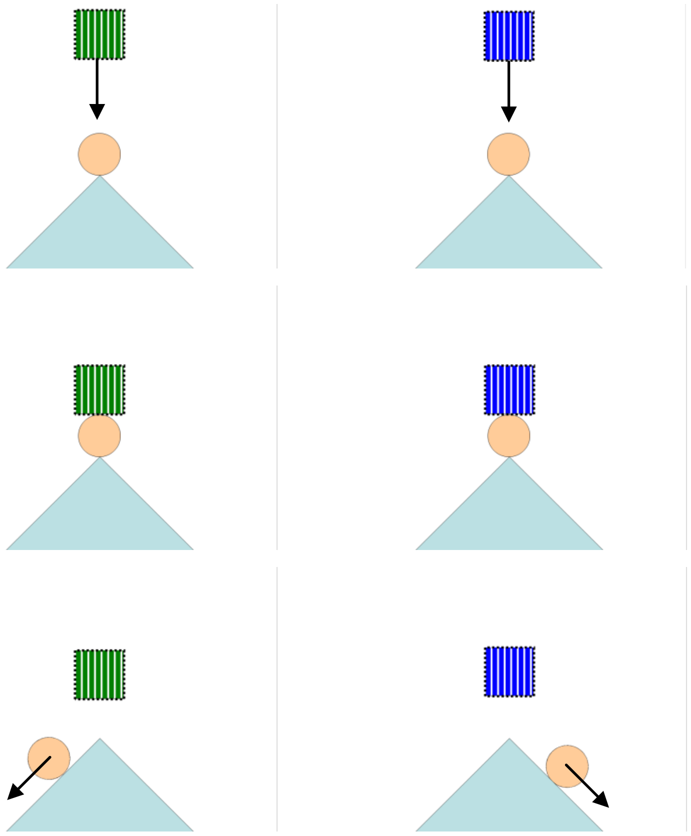

Figure 4 Experiment 1 Familiarization Phase Stimuli. In the familiarization phase green objects push the circle towards left, whereas blue objects push towards right.

Participants were divided into the following three experimental groups according to the instructions given at the beginning of the familiarization phase:

Color Group (n=12): try to memorize the objects and name the color of the critical object aloud.
Border Group (n=12): to memorize the objects and name the border of the critical object aloud.
Control Group (n=12): try to memorize the objects.

Simon phase: There was a total number of 8 objects that were used as stimuli in this phase. Each object was a triangle with a unique combination of color (blue or green), inside pattern (dotted or spiral), and border (straight or dashed). A total number of 48 objects were presented in 6 cycles (8 objects x 6 cycles). The objects were presented at the center of the screen. The participants were instructed to press left or right keys in accordance with the inside pattern.

"Congruent" Trials	"Incongruent" Trials

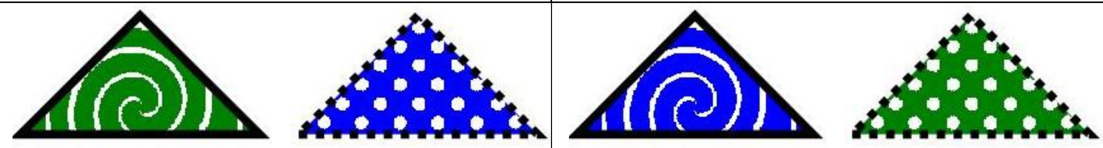

Figure 5 Experiment 1 Simon Phase Stimuli. Examples of "congruent" and "incongruent" trials in the Simon phase when participants were to press left key for spiral patterns and right key for dotted patterns.

Results and Discussion

The data[3] was analyzed by a three-way mixed Analysis of Variance (ANOVA), with congruency (congruent, incongruent trials) and blocks (6 blocks of 8 trials) as within-subject variables and experimental group (color, border, control) as between-subject variable. Neither the mains effects of congruency and experimental group, nor their interaction was significant.[4]

The awareness of the participants in the familiarization phase rule was assessed via post-experimental interviews. Table 1 shows the distribution of aware and unaware participants for each group. It can be seen that most of the participants become aware of the rule. This result differs from the above reported study of Eren and Hohenberger (2009) where almost half of the participants could report the regularity in the familiarization phase. However, participants in that study were just instructed to memorize the objects without any naming. So, the difference suggests that with such a simple regularity, the rule would be extracted easily by all participants – even when directing participants to attend to the rule-irrelevant features of the stimuli.

Table 1 Numbers of participants in each instruction group with respect to reported awareness in Experiment 1

	Unaware	Aware
Color	3	9
Border	4	8
Control	3	9

The data was analyzed by a three-way mixed Analysis of Variance (ANOVA), with congruency (congruent, incongruent trials) and blocks (6 blocks of 8 trials each) as

[3] Error trials are excluded from the analysis. The data of each participant are normalized by excluding reactions times that are 2 SD below or above the mean reaction time of the participant. Same procedure is applied for all experiments.

[4] Here, and in the following experiments, we renounce on providing test statistics for insignificant results.

within-subject variables and reported awareness of the rule as a between-subject variable. Neither the mains effects of congruency and reported awareness, nor their interaction was significant. Once again, the results differed from the Eren and Hohenberger (2009) study where there was a significant congruency and awareness interaction. One factor explaining this difference may be there being few participants who could not report the rule in the present experiment. Also, the relatively easy extraction of such a simple rule may have caused some participants to ignore subsequent trials once they become aware of the rule, which in turn may have hampered the formation of short-term associations that would show their influence in the Simon phase.

3.1.2. Experiment 2

The results of Experiment 1 showed that the feature naming instruction does not enable a controlled manipulation of awareness since directing participants even to an irrelevant feature of the stimuli does not prevent them to become aware of the regularity. As an alternative, the participants in the present experiment were presented different numbers of trials in the familiarization phase. That is, we decreased the number of trials (slides) that are presented to a group of participants in the familiarization phase in order to hinder them to become aware of the regularity. In the following experiment, there were three groups that were presented either all 3 cycles or less (1 or 2 cycles).

Participants

32 students (16 male, 16 female, age range: 19-31 years) of Middle East Technical University participated in the experiment. They reported to have normal or corrected-to-normal vision.

Procedure and the stimuli

Familiarization Phase: The presented stimuli were identical with the ones in the above experiment (see Figure 4). The participants were divided into three experimental groups with respect to the number of cycles that were presented, either one (n=10), two (n=10), or three (n=12) cycles.[5] A cycle in the slide show was completed when all 12 objects had been presented (i.e. a cycle consisted of 24 slides with 12 object and 12 fixation slides). All participants were instructed just to memorize the objects without any additional instructions that may direct them towards the stimuli features.

Simon phase: The stimuli and the presentation of the stimuli were identical with the ones in the above experiment (see Figure 4).

[5] The data of the control group in the previous experiment was used as the 3-cycle condition data.

Results and Discussion

The data was analyzed by a three-way mixed Analysis of Variance (ANOVA), where congruency (congruent, incongruent trials) and blocks (6 blocks of 8 trials each) were within-subject variables and experimental group was a between-subject variable. Neither the mains effects of congruency and experimental group, nor their interaction was significant.

The awareness of the participants in the familiarization phase rule was assessed *via* post-experimental interviews. Table 2 shows the distribution of aware and unaware participants for each group. A chi-square test revealed that the difference of the numbers of the participants who became aware with respect to group was significant ($\chi^2(2) = 6.61$, $p < .05$). As can be seen in Table 2, participants were more likely to become aware of the rule when they had been presented the stimuli for 2 or 3 cycles, but not 1 cycle.

Table 2 Numbers of participants in each instruction group with respect to reported awareness in Experiment 2

	Unaware	Aware
1-Cycle	7	3
2-Cycles	2	8
3-Cycles	3	9

The data is analyzed by a three-way mixed Analysis of Variance (ANOVA), where the congruency (congruent, incongruent trials) and blocks (6 blocks of 8 trials each) are within-subject variables and awareness of the rule is a between-subject variable. Neither the main effects of congruency and reported awareness, nor their interaction is significant.

Although changing the number of presented stimuli turned out to be a successful manipulation of awareness, it is also important to note that the difference was actually between the 1-cycle condition on the one hand and the 2- and 3-cycle conditions on the other hand. This point, in turn, may be considered as one the reasons why the results did not reveal any significant congruency effect. That is, presenting just 1 cycle (i.e. only 12 trials) may not be enough to influence the behaviour of the participants in the subsequent Simon phase. Besides, as similar to the previous experiment, the relatively easy extraction of such a simple rule may cause some participants to ignore subsequent trials once they had become aware of the rule. Therefore, in Experiment 3, we devised a more complex rule.

3.1.3. Experiment 3: Complex Rule

Experiment 2 suggested that although changing the number of trials that are presented to the participants can manipulate the awareness of the rule, it may also hinder the possible influence of the familiarization phase on the subsequent Simon phase. Besides, Experiment 1 showed that directing participants to the rule-relevant or -irrelevant features of the stimuli was not working as a successful manipulation of awareness with a simple rule. So, in the following experiment, we increased the number of rule-relevant features of the stimuli to increase the complexity of the rule. The movement direction in the present experiment was now dependent on two features (i.e. color and shape of the critical object), and participants were either directed to these features or to a rule-irrelevant feature (as in Experiment 1).

Participants

28 students (11 male, 17 female, age range: 19-32 years) of Middle East Technical University participated in the experiment. They reported to have normal or corrected-to-normal vision.

Procedure and the stimuli

Familiarization Phase: The basic pattern of the stimuli presentation of this phase was similar with the one to the above experiments (see Figure 3). That is, in each slide a critical object hit a creamy colored circular object situated on top of a pyramid whereupon the latter fell either to the left, the right, or downwards. Yet, in the present experiment, the falling direction of the creamy circular object depended both on the color and the shape of the first object, namely the creamy circular object fell to the left if the critical object was a green triangle, to the right if it was a blue square, and downwards if it was a green square or blue triangle[6].

There was a total number of 24 different critical objects that were composed of a unique combination of color (blue or green), shape (square or triangle), inside pattern (vertical, horizontal or diagonal), and border (straight or dashed).

A cycle in the slide show was completed when all 24 objects had been presented. A fixation slide, i.e. a slide only with a fixation cross at the initial place of the critical object, is presented between all object slides. A total of 3 cycles was presented in the familiarization phase.

Participants were divided into the following three experimental groups according to the instructions given at the beginning of the familiarization phase:

Color and Shape Group (n=9): try to memorize the objects and name the color and shape of the critical object aloud.
Border Group (n=10): try to memorize the objects and name the border of the critical object aloud.
Control Group (n=9): try to memorize the objects.

Simon phase: Since the rule now depended both on color and shape, rather than just color, the stimuli in this phase were changed accordingly. There was a total number of 8 objects that were used as stimuli in this phase. Each object was a green triangle

[6] The inclusion of green squares and blue triangles was necessary for the design of the experiment in order to prevent the rule to be reduced to a simpler one (e.g. green objects fall to the left and blue objects fall to the right).

or a blue square with a unique combination of inside pattern (dotted or spiral), and border (straight or dashed). A total number of 96 objects were presented in 12 cycles (8 objects x 12 cycles). The objects were presented at the center of the screen. The participants were instructed to press left or right keys in accordance with the inside pattern. Figure 6 shows the “congruent” and “incongruent” stimuli.

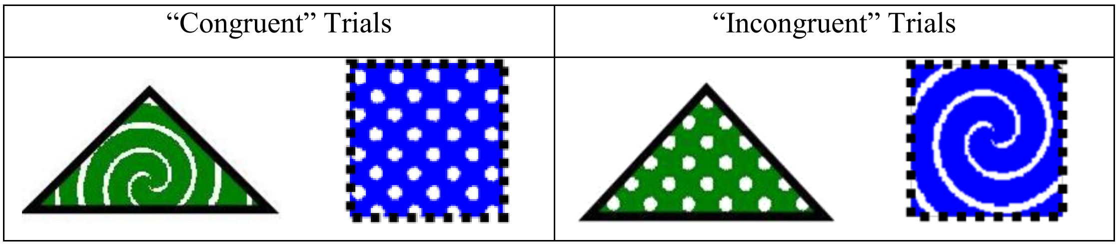

Figure 6 Experiment 3 Simon Phase Stimuli. Examples of “congruent” and “incongruent” trials in the Simon phase when participants were to press the left key for spiral patterns and the right key for dotted patterns.

Results and Discussion

The data was analyzed by a three-way mixed Analysis of Variance (ANOVA), where congruency (congruent, incongruent trials) and blocks (6 blocks of 16 trials each) were within-subject variables and experimental group was a between-subject variable. Neither the mains effects of congruency and experimental group, nor their interaction was significant.

The awareness of the participants in the familiarization phase rule was assessed via post-experimental interviews. Table 3 shows the distribution of aware and unaware participants for each group.

Table 3 Numbers of participants in each instruction group with respect to reported awareness in Experiment 3

	Unaware	Aware
Color and Shape	5	4
Border	10	0
Control	6	3

The data is analyzed by a three-way mixed Analysis of Variance (ANOVA), where the congruency (congruent, incongruent trials) and blocks (6 blocks of 16 trials each) are within-subject variables and awareness of the rule is a between-subject variable.

Neither the mains effects of congruency and reported awareness, nor their interaction is significant.

The results suggest that increasing the number of rule relevant features, hinders the extraction of the rule so severely that no participants that are distracted away from the rule became aware of it. However, the number of aware participants in the group that had been directed towards detecting the rule, was also still quite low. Therefore, in Experiment 4, we sought to increase the chance to detect the rule.

3.1.4. Experiment 4

In the following experiment the instructions that participants received were changed so that the extraction of the rule in the familiarization phase became easier for the group that was directed towards the rule. Particularly, all participants were instructed about the existence of the rule - but not which rule. Participants were also asked to predict the falling direction of the stimuli. It is worth noting that with these instructions, the familiarization phase was not a proper implicit learning task any more. Rather it was now an intentional learning task that may result in explicit or implicit knowledge.

Furthermore, the stimuli used in both the familiarization phase and the Simon phase were changed. Now in the familiarization phase there was only one object that moved (instead one feature-less object being pushed by another object which carried the critical features). In this way, we reduced the processing load for the participants and focused participants' attention directly on the relation between the critical feature combination (color, shape) and the spatial feature (left, right).

The stimuli of the Simon phase were changed so that they became identical to the objects in the familiarization phase.

Participants

30 students (17 male, 13 female, age range: 19-32 years) of Middle East Technical University participated in the experiment. However, the data for 3 of them (all from the Border Group) were excluded from the analysis since their performance in the Simon task indicated that they confused the inside pattern (horizontal/vertical) and the correspondence with the correct key (left/right). All of the participants reported to have normal or corrected-to-normal vision.

Procedure and the stimuli

Familiarization Phase: In the familiarization phase participants were presented a slide show. There was a total number of 12 different objects that were used as stimuli. Each object was composed of a unique combination of shape (square or triangle), color (blue or green), inside pattern (vertical or horizontal), and border (straight or dashed). A cycle in the slide show was completed when all 12 objects had been presented (i.e. a cycle consisted of 12 slides). 5 cycles were presented in the familiarization phase. For each slide, an object first appeared at the top of the screen. It then began to fall towards the middle, where a pyramid was located, and then fell either to the left or to the right of the pyramid or continued its straight movement path downwards. A fixation slide, i.e. a slide only with a fixation cross at the initial place of the critical object, is presented between all object slides.

The direction of the falling movement depended on the particular combination of the color and the shape of the objects. The green triangles fell to the left, whereas the blue squares fell to the right. There were also green squares and blue triangles that fell downwards. (Figure 7 shows snapshots from the familiarization phase).

At the beginning of the familiarization phase, all participants were informed about the existence of a rule – but not which rule. They were also asked to predict aloud where an object will fall as soon as they saw the object.

The groups were instructed differently as follows:

Color and Shape Group (n=10): verbally predict the direction of fall and name the color and shape of the object aloud.
Border Group (n=7): verbally predict the direction of fall and name the border of the object aloud.
Control Group (n=10): verbally predict the direction of fall.

During this phase the verbatim direction predictions of the participants were recorded manually by the experimenter. After the completion of the familiarization phase, participants were transferred to the Simon task.

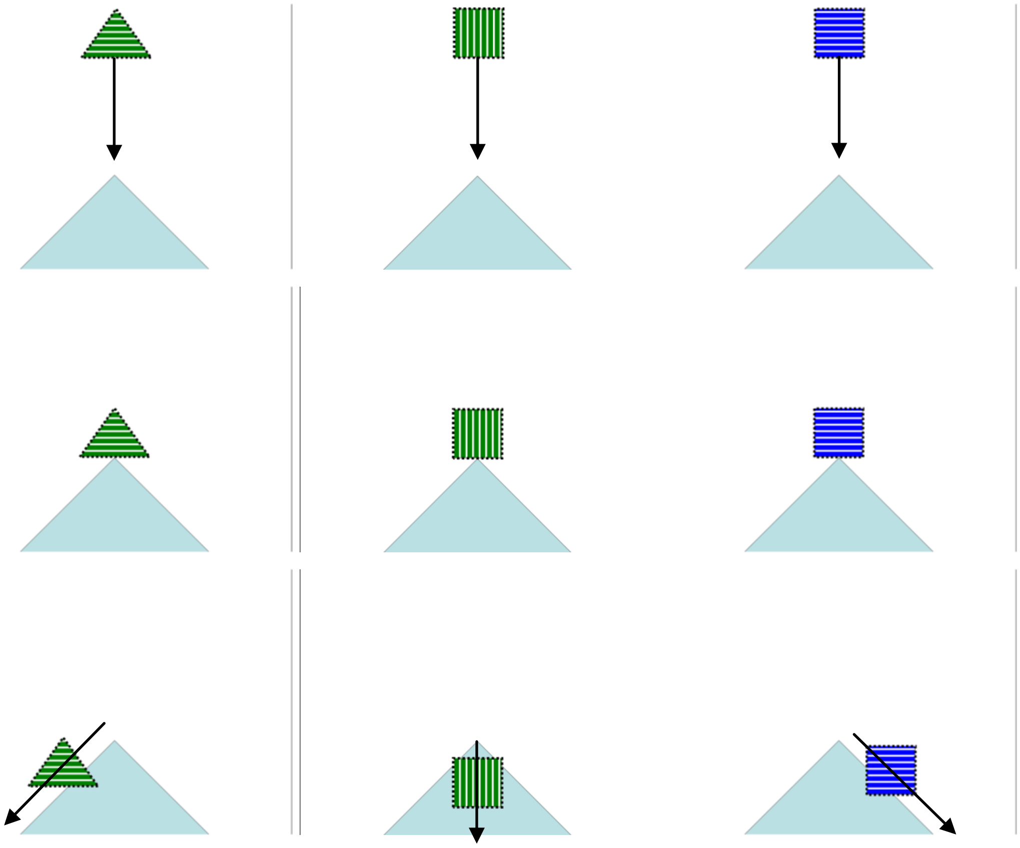

Figure 7 Experiment 4 Familiarization Phase Stimuli. In the familiarization phase green triangles fall to the left, blue squares fall to the right, and green squares and blue triangles fall downwards.

Simon phase: The stimuli in the Simon phase were the same as in the familiarization phase. The objects were presented at the center of the screen. A total number of 96 objects was presented in 12 cycles (8 objects x 12 cycles)). The participants were instructed to press left or right keys in accordance with the inside pattern. Figure 8 shows the “congruent” and “incongruent” stimuli.

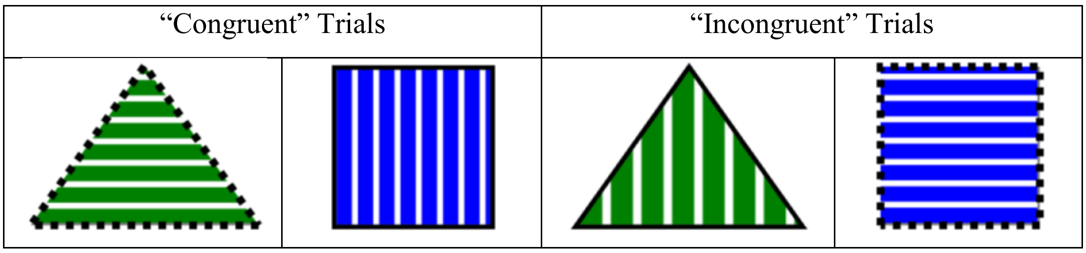

Figure 8 Experiment 4 Simon Phase Stimuli. Examples of “congruent” and “incongruent” trials in the Simon phase when participants were to press the left key for horizontal patterns and the right key for vertical patterns.

Results and Discussion

The data was analyzed by a three-way mixed Analysis of Variance (ANOVA), where congruency (congruent, incongruent trials) and blocks (6 blocks of 16 trials each) were within-subject variables and experimental group was a between-subject variable. Neither the mains effects of congruency and experimental group, nor their interaction was significant.

The awareness of the participants on the familiarization phase rule was assessed via post-experimental interviews. In the control group, only one participant out of 10 can reported the rule, and in the color and shape group 7 participants out of 10 could report the rule. In the border group only one participant out of 7 could report the rule. This result suggests that participants mostly did not become aware of the rule if their attention was not directed towards the object features that were relevant to the rule (i.e. color and shape).

As stated in the procedure section, the direction predictions of the participants were recorded by the experimenter. This allowed us to obtain the percentage of accuracy of prediction for each subject. We use the percentage of correct predictions that a participant reported in the last two cycles of the familiarization phase as the prediction performance for this participant. When the prediction performance of each participant was tested (with a binomial test), it was revealed that 10 (out of 18) who could not report the rule had an accuracy value above chance performance (chance level was taken as 33%, given that there were three possible movement directions: left, right, and downward).

It is worth noting that – among the participants who could report the rule – only one participant from the border group had an accuracy value above chance performance (see Table 4). This indicates that directing participants' attention towards irrelevant features (i.e. border) had two effects. It not only hindered the possibility of discovering the rule, but also decreased the performance in the prediction.

Table 4 Numbers of participants in each instruction group with respect to reported awareness and their prediction performance in Experiment 4.

	Unaware		Aware
	Below Chance	Above Chance	
Color and Shape	0	3	7
Border	5	1	1
Control	3	6	1

The data was analyzed by a three-way mixed Analysis of Variance (ANOVA), with congruency (congruent, incongruent trials) and blocks (6 blocks of 16 trials each) as within-subject variables and awareness of the rule as a between-subject variable. Neither the main effect of congruency, nor the interaction effect of congruency and awareness produced any statistical significance when the data of all subjects were analyzed together.

The data of the participants who could or could not report the rule, and had an accuracy value above or below chance performance were also separately analyzed. In that respect, there were three groups: (1) “not aware and below chance” participants, who could not report the rule and had an accuracy value below chance performance, (2) “not aware and above chance” participants, who could not report the rule but had an accuracy value above chance performance, and (3) “aware” participants, who could report the rule and accordingly had an accuracy value above chance. When the data of “not aware and below chance” participants were analyzed, the results revealed a significant congruency effect (F (1, 7) = 7.45, p< .05, η_p^2= 0.516). However, this effect was a reverse Simon effect (of 20 ms). That is, the participants were faster in incongruent trials (mean RT=558 ms, SE=33.71) than in congruent trials (mean RT=578 ms, SE=33.06).

The results of “not aware and above chance” participants revealed a significant congruency effect (F (1, 9) = 12.02, p< .00, η_p^2= 0.572), i.e. a Simon effect (of 47 ms). That is, the short-term associations formed in the familiarization phase influenced the performance on the later task and resulted in a Simon effect.

The results of the analysis of the “aware” group did not reveal any significant effect. However, it is worth noting the pattern of the Simon effect for these participants. When the data of these participant was examined, it was seen that 6 of the participants tended to show a reverse Simon effect (i.e. faster in incongruent trials), whereas 3 tended to show a normal Simon effect. Thus, these contradictory effects cancelled each other out and, consequently, no overall Simon effect was observed in the group of “aware” participants.

3.1.5. Experiment 5: A test for Stimuli

To further explore the nature of the congruency effects revealed in Experiment 4, an experiment was conducted to examine the reactions times for the stimuli that had been used in the Simon phase without any familiarization phase. It had been expected that a comparison of reaction times from this experiment with the previous ones would give us information about whether the congruency effects were due to the facilitation for congruent trials, or to the interference for incongruent trials, or both. However, instead of providing this information the results revealed that the inside patterns of the stimuli had an unpredicted interference in the Simon task.

Participants

7 students (3 male, 4 female, age range: 20-29 years) of Middle East Technical University participated in the experiment. All of the participants reported to have normal or corrected-to-normal vision.

Procedure

Participants just did the Simon phase without any previous familiarization phase. As stimuli, there was a total number of 8 objects each of which was a unique combination of shape (square or triangle), color (blue or green), inside pattern (horizontal or vertical), and border (straight or dashed) (see Figure 8). As in the basic design, each object appeared at the center of the screen and participants pressed left or right keys in accordance with the inside patterns of the objects. There was a total number of 96 trials (8 objects x 12 cycles).

The participants were divided into two groups differing with respect to response mapping, where one group was to press the right key for horizontal patterns and the left key for vertical patterns; the other group did it vice-versa.

Results

Since there was no familiarization phase in which associations between object features and direction features could be formed, the stimuli did not have any congruency attribute. However, the stimuli were categorized in accordance with a hypothetical congruency determined by the congruency attribute that they would have, if there had been a previous familiarization phase. As expected, a repeated measures test on this hypothetical congruency revealed no significant congruency effect.

To investigate any undesired effect that the stimuli might have on reaction times, due to the spatial features of the horizontal and vertical pattern, the data was analyzed by a two-way mixed ANOVA where response direction (left key/right key) was a within-subjects variable, and response mapping (i.e. press to the right for the horizontal inside patterns and press to the left for the vertical inside patterns, or vice-versa) was a between-subjects variable. Results revealed a significant response direction and mapping interaction effect (F (1, 5) = 14.17, p< .05, η_p^2= 0.739). Figure 9 indicates that when the response rule is to press to right for the horizontal inside patterns and to left for the vertical inside patterns, to the right responses are faster than to the left responses. However, when the response rule is to press to right for the vertical inside patterns and to left for the horizontal inside patterns to the right responses are slower than to the left responses. The pattern of the former group could be anticipated since the participants are right-handed. However, the pattern of the other group showed the unexpected effect that the participants were slower when they were to give a right response to vertical patterns. This pattern is in need of an explanation. The pattern may be a result of a relevant stimulus feature (i.e. inside pattern) and a response set compatibility effect. That is, as left and right key responses were situated in the horizontal dimension this might have caused an interference effect when the relevant stimulus feature had a vertical pattern. However, independent of the explanation, it is clear that the stimuli themselves had an effect on the reaction times in the Simon phase that might interfere with the congruency effect that this study explores.

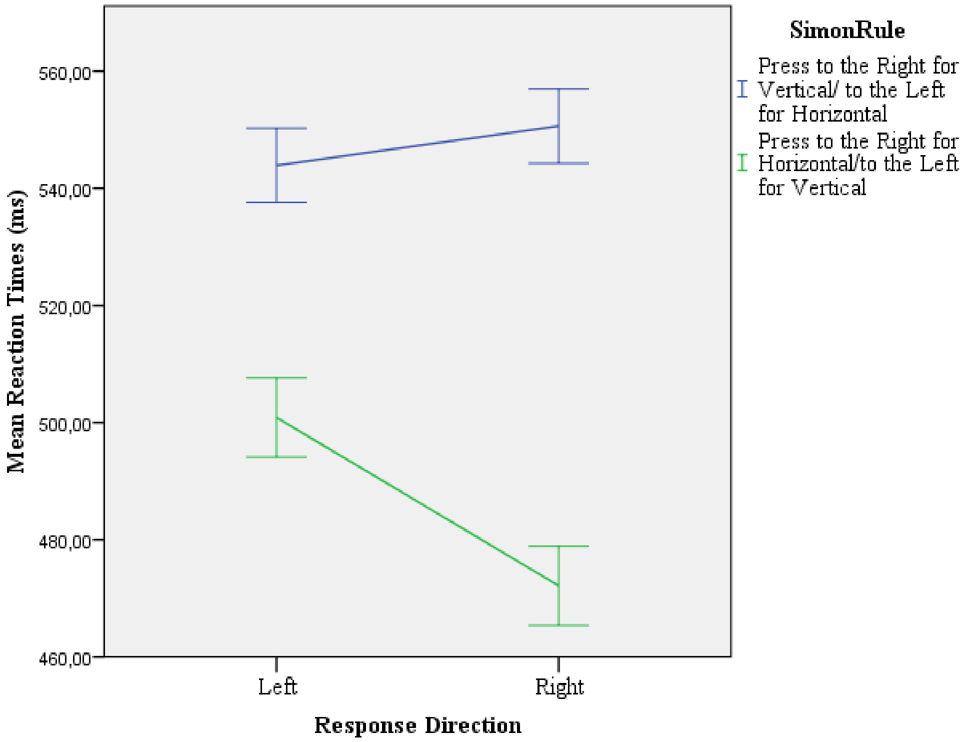

Figure 9 Experiment 5 Response Direction*Response Mapping Interaction Effect. Error bars represent SE

3.2. Current Design

As a result of the previous five experiments, the stimuli and design of the familiarization phase were changed accordingly. The current experiment design differs from the previous one in three respects. Firstly, the inside patterns of the stimuli were changed from horizontal and vertical to spiral and dotted – so as to avoid any confound with the spatial dimension of the stripes in the stimuli themselves. Furthermore, the paths of the movement in the familiarization phase were changed from a diagonal falling movement to a straight movement due to the possibility that the former may cause an ambiguity because it not only involved the horizontal dimension (left and right) but also the vertical dimension (down). Lastly, a new part that enabled the assessment of consciousness via subjective confidence ratings was added at the end of the experiment.

3.2.1. Experiment 6

Participants

53 students (22 male, 31 female, age range: 19-33 years) of Samsun Ondokuz Mayıs University participated in the experiment. However, the data for 7 of them (3 from Control Group, and 4 from Color and Shape group) were excluded from the analysis since their performance in the Simon task indicated that they confused the inside pattern (spiral/dotted) and correct key (left/right) correspondences. All of the participants reported to have normal or corrected-to-normal vision.

Procedure

Familiarization Phase: In the familiarization phase participants were presented a slide show. There was a total number of 12 different objects that were used as stimuli. Each object was composed of a unique combination of shape (square or triangle), color (blue or green), inside pattern (spiral or dotted), and border (straight or dashed). A cycle in the slide show was completed when all 12 objects had been presented (i.e. a cycle consisted of 12 slides). 8 cycles were presented in the familiarization phase. For each slide, an object first appeared at the center of the screen. After a 1 second delay it began to move to the left or to the right or downwards. A fixation slide, i.e. a slide only with a fixation cross at the initial place of the object, is presented between all object slides.

The direction of the movement depended on the particular combination of the color and the shape of the objects. The green triangles moved to the left, whereas the blue squares moved to the right. There were also green squares and blue triangles that moved downwards. (Figure 10 shows snapshots from the familiarization phase).

Figure 10 Experiment 6 Familiarization Phase Stimuli. In the familiarization phase green triangles moved to the left, whereas blue squares moved to the right. Upper panel: start of the movement; Lower panel: end of the movement.

At the beginning of the familiarization phase, all three groups were informed about the existence of a rule – but not the exact rule. The groups were instructed differently as follows:

Color and Shape Group (n=15): verbally predict the direction of the movement and name the color and shape of the object aloud. It is expected that naming the color and shape directs this group towards discovering the rule.

Border Group (n=13): verbally predict the direction of the movement and name the border of the object aloud. It is expected that naming the border distracts this group away from discovering the rule.

Control Group (n=13): verbally predict the direction of the movement.

During the familiarization phase the verbatim direction predictions of the participants were recorded manually by the experimenter.

Simon phase: The stimuli in the Simon phase were the same as in the familiarization phase. The objects were presented at the center of the screen. A total number of 216 objects was presented in 18 cycles. The participants were instructed to press left or right keys in accordance with the inside pattern. Figure 11 shows the "congruent" and "incongruent" stimuli.

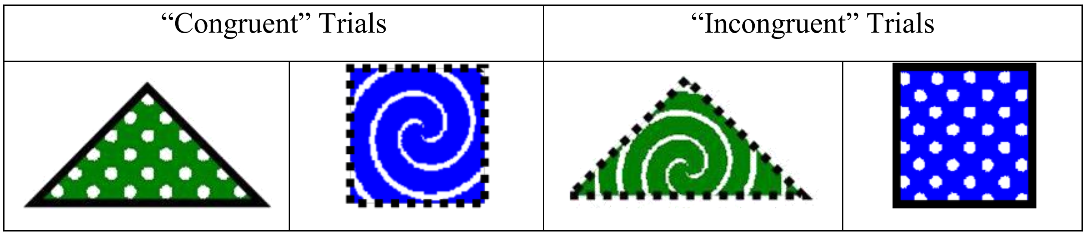

Figure 11 Experiment 6 Simon Phase Stimuli. Examples of "congruent" and "incongruent" trials in the Simon phase when participants were to press the left key for dotted patterns and the right key for spiral patterns.

After the completion of the Simon phase, participants were transferred to the confidence ratings phase. For that purpose, all 12 objects that were used as stimuli were presented one by one at the center of the screen. For each object, participants were instructed to first state the direction of the movement of the object in the familiarization phase and then report a confidence rating for their answer. For the confidence ratings, participants were asked "How sure are you of your answer?" and expected to indicate their confidence with a number on a Likert scale ranging from 1 to 5 where 1 referred to "I am totally guessing" and 5 to "I am sure".

Results

Reaction Times

The data of 5 more participants (2 from the Control group, 1 from the Color and Shape group, and 2 from the Border group) had to be excluded from the analysis due to excessive error rates (10%). Accordingly, although the experiment had been conducted with a total number of 53 participants, the results reported here are of the data of 41 participants (15 from the Color and Shape group, 13 from the Border group, and 13 from the Control group, respectively).

The reaction time data of the Simon task was analyzed by a three-way mixed Analysis of Variance (ANOVA), with congruency (congruent, incongruent trials) and blocks (9 blocks of 24 trials each) as within-subject variables and experimental group as a between-subject variable. The results revealed a significant main effect of congruency (F (1, 38) = 8.01, p< .01, η_p^2= 0.174), i.e., a Simon effect (of 10.64 ms, SE=3.76).

Moreover, although the interaction effect of congruency and group was not statistically significant (p> .50), separate t-tests were conducted for each group. The results showed that there was a significant congruency effect (of 10 ms, SE=3.85) only for the Color and Shape group, t (14) =-2.60, p<.05. Figure 12 shows the congruency effects with standard errors for each group.

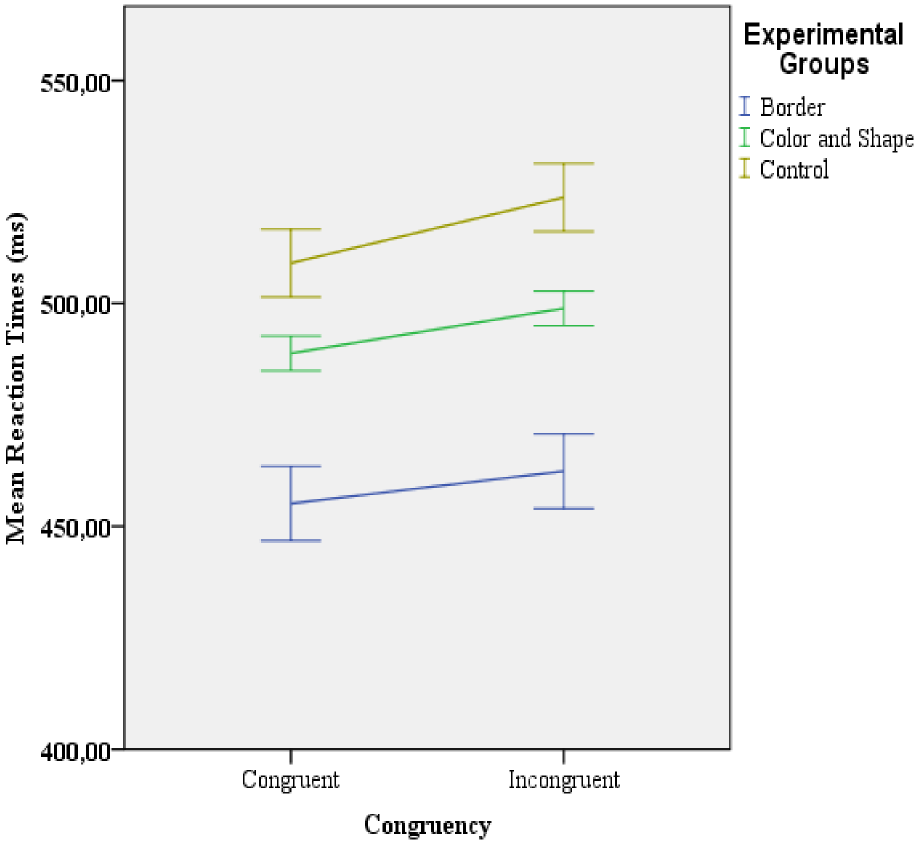

Figure 12 Experiment 6 Congruency Effects for Experimental Groups. Error bars represent SE. The effect is significant only for Color and Shape group.

As similar to the previous study, the awareness of the participants of the rule in the familiarization phase was assessed via post-experimental interviews. In the control group, 6 participants out of 13 could report the rule, in the color and shape group 14 participants out of 15 could report the rule. On the other hand, none of the 13 participants in the border group could report the rule (See Table 5). So, the manipulation of rule awareness by instructions (that directs participants to or distracts their attention away from the relevant features) was successful as also revealed by a chi-square test (χ^2(2) =24.33, p<.001).

Table 5 Numbers of participants in each instruction group with respect to reported awareness and their prediction performance in Experiment 6.

	Unaware		Aware
	Below Chance	Above Chance	
Color and Shape	1	0	14
Border	4	9	0
Control	3	4	6

A three-way mixed ANOVA, with congruency (congruent, incongruent trials) and blocks (9 blocks of 24 trials each) as within-subject variables and awareness of the rule as a between-subject variable was conducted. The results revealed a significant main effect of congruency of 10 ms (SE=3.75), F (1, 38) = 7.99, p< .01, η_p^2= 0.170. Similar to the instruction group analysis above, separate t-tests were conducted for rule-aware and -unaware participants. Consistent with the instruction group analysis, the results showed that there was a significant congruency effect (of 12 ms, SE=4.97) only for the aware participants, t (19) =-2.39, p<.05.

In line with the previous study (i.e. Experiment 4), the data of the participants who could or could not report the rule, and had an accuracy value above or below the chance performance were also separately analyzed. However, different to the previous study neither the "not aware and below chance", nor the "not aware and above chance" group showed a significant Simon effect. Figure 13 shows the congruency effects with standard errors for each post-experimental group.

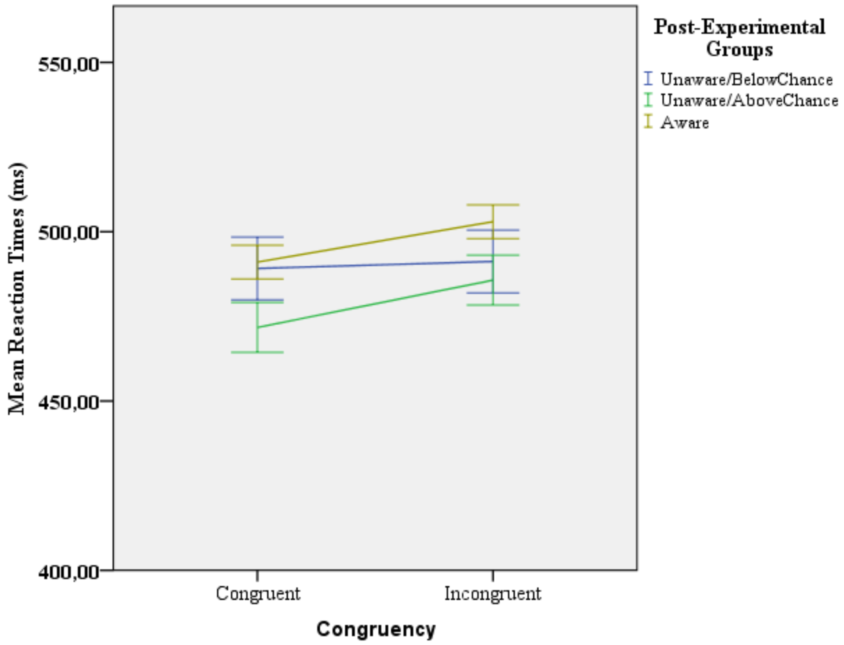

Figure 13 Experiment 6 Congruency Effects for Post-Experimental Groups. Error bars represent SE. Note that the effect is significant only for the aware participants.

Measures Analysis

As reported above, the manipulation of rule awareness by instructions between groups is successful if the rule awareness is assessed via verbal reports. However, in line with the literature on consciousness measures, several analyses with other measures were conducted to our test instruction manipulation.

A one-way ANOVA on the accuracy of prediction performance with group as a between-subjects variable, revealed a significant main effect of group, F (2, 38) = 20.16, $p<$ .01. The color and shape group showed better performance (mean performance percentage=85%, *SE*=4.23) than the control group (mean performance percentage=62%, *SE*=5.81), and the border group showed the worst performance (mean performance percentage=45%, *SE*=3.21). It is worth to note that, although this result is in line with the reported awareness (so may be considered as trivial), it also indicates that all the groups showed an above-chance performance when the performance was analyzed on a group basis. Also, the results of mean comparison analyses performed on performance percentage against chance level (i.e. 33%) showed that both aware participants (mean difference of performance percentage=51.50, $t(20)=16.23$, $p<.01$) and unaware participants (mean difference of performance percentage=13.85, $t(20)=7.72$, $p<.01$) showed above chance performance.

For the guessing criterion, a low confidence performance percentage was obtained from the performance of participants in the trials of confidence ratings phase where they report a low confidence (i.e. 1 or 2 over 5). As explained in the Chapter 2.1., the guessing criterion indicates that if the participants perform above chance even when they are not confident about their choice, this means that they have implicit knowledge. To assess the awareness of the rule according to this criterion, separate t-tests were conducted for each group against chance performance (33%). These tests do not lead to any significant results. Also, a one-way ANOVA conducted on this low confidence performance with group as a between-subjects variable revealed no significant effect.

For the zero-correlation criterion, separate correlation analyses were conducted on performance and confidence ratings of participants for each group. Analyses revealed that the correlation was significant for the Color and Shape group ($r=.75$, $p<.01$) and the Control group ($r=.82$, $p<.01$), whereas there was not any significant correlation in the Border group ($p>.3$).

Discussion

As stated above, since the stimuli in the Simon phase are presented at the center of the screen, they do not have any spatial feature by themselves. So, the observed congruency effect can only be due to the short-term associations that are formed during the familiarization phase. In that sense, the significant congruency effect clearly shows both that short-term associations are formed and that they influence the behaviour of the participants in the Simon phase.

Also, although there was no significant congruency and group interaction effect, separate t-test analyses revealed that the congruency effect was significant in two analyses: in the first "group" analyses, the subgroup of the Color and Shape group whose attention had been directed towards the critical features showed a regular Simon effect and in the second "awareness" analysis, it was the Aware group that showed the effect. Note that the Aware group mostly consists of members of the Color and Shape group, but also of members of the Control group. Both these results imply that awareness of the rule is necessary for previously formed short-term associations to show their effect in the subsequent Simon phase. One possible objection to this interpretation of the results may be that the lack of Simon effect may not be a result of lack of awareness of the rule, but rather may be due to short-term associations not being formed at all. However, the result of the prediction performance analysis, which revealed that all groups performed better than chance, shows that participants in all groups had at least (some) implicit knowledge of the rule and hence the associations were formed for all of them, albeit with different strength.

As mentioned in Chapter 2.4, in Vu 2011 (Experiment 2) when participants practiced a non-corresponding mapping (i.e. a Simon task where all trials were incongruent) first, and then were transferred to a Simon task, the reversal of Simon effect occurred only for the participants who had become aware of the non-corresponding mapping. Vu speculates on this finding as being the result of a re-instantiation of a "respond to the opposite strategy." In the scope of the present experiment it is not clear whether participants needed such a strategy for their performance in the familiarization phase. However, the predictions of the participants can be considered as verbal responses (see general discussion for details). In such a case, the adaptation of a strategy to predict in accordance with the rule seems plausible for the rule-aware group.

Independent of the particular explanation, the results of the present experiment indicate that although implicit associations formed as a result of the rule can boost the performance in a task, awareness of the rule is required for the rule to affect participants' performance in another task.

The results of the guessing criterion indicate that participants in neither groups showed an above-chance performance while they were not confident. This finding implies that none of the participants had implicit knowledge of the rule. The results are not surprising for the color and shape group, since all but one participants of this group were aware of the rule. There were only 4 participants (out of 15) who reported low confidence for their responses. The results for the other groups cannot be explained in the same vein since their prediction performance indicated that they had implicit knowledge. However, the low number of trials in the confidence measures part (i.e. there were only 12 trials one for each object), may not be sufficient to reveal any effect.

On the other hand, as different from the guessing criteria, the result of the zero-correlation criterion is consistent with the above-chance prediction performance of these participants. However, it is better to use this criterion to assess the explicit knowledge rather than implicit knowledge since the non-significant correlation may be due to the insufficient statistical power especially when considering the low number of trials.

3.2.2. Experiment 7

The results of the previous experiment show that awareness of the rule is necessary to see the congruency effect in the later Simon task. Another interesting question is whether the awareness itself is sufficient for the occurrence of this effect, or whether it depends on the particular way short-term associations and awareness emerge. Different ways of forming them are also supposed to lead to rule representations of varying strengths. Accordingly, the present experiment was conducted to further investigate the factors influencing how the awareness of the rule and the short-term associations that are expected to be formed in the familiarization phase are acquired.

Particularly, two experimental groups in the experiment were manipulated so that all of them had the explicit knowledge of the rule before the Simon phase. However, they were expected to form short-term associations of different strengths due to receiving different instructions in the familiarization phase.

As similar to the previous experiments, the two groups in this experiment differed with respect to the instructions in the familiarization phase. One group was told the rule at the beginning of the familiarization phase and was asked to state the movement direction based on the rule throughout this phase, in each trial. The other group was distracted away from the rule, and was told the rule only at the end of the familiarization phase. The short-term associations that are to be formed were expected to be stronger for the first group, and weaker for the latter one.

If explicit knowledge of the rule is sufficient for the subsequent effect in the Simon phase, then both groups are expected to show this effect. On the other hand, if the practice that provides stronger short-term associations is also necessary then only the group that was told the rule at the beginning of the familiarization phase would show the effect

Participants

30 students (15 male, 15 female, age range: 19-37 years) of Middle East Technical University participated in the experiment. All of the participants reported to have normal or corrected-to-normal vision.

Procedure

The stimuli and the presentation of the stimuli were identical with those in the above experiment (i.e. Experiment 6). The participants were divided into two experimental groups with respect to the following different instructions in the familiarization phase.

Group1 (n=15): was told what the rule was at the beginning of the familiarization phase and were asked to state the movement direction, and the color and shape of the objects aloud for each slide in the familiarization phase.

Group2 (n=15): was not informed about the existence of the rule and were asked just to state the border of the object aloud. At the end of the familiarization phase they were informed about the existence of the rule and told the rule explicitly.

After the completion of the familiarization phase, participants were transferred to the Simon task.

Results

The data was analyzed by a three-way mixed Analysis of Variance (ANOVA), with congruency (congruent, incongruent trials) and blocks (9 blocks of 16 trials each) as within-subject variables and experimental group as a between-subject variable. Neither the main effects of congruency and experimental group, nor their interaction was significant. Separate t-test analyses of congruency for the groups also did not reveal any significant effect. Figure 14 shows the congruency effects with standard errors for each group.

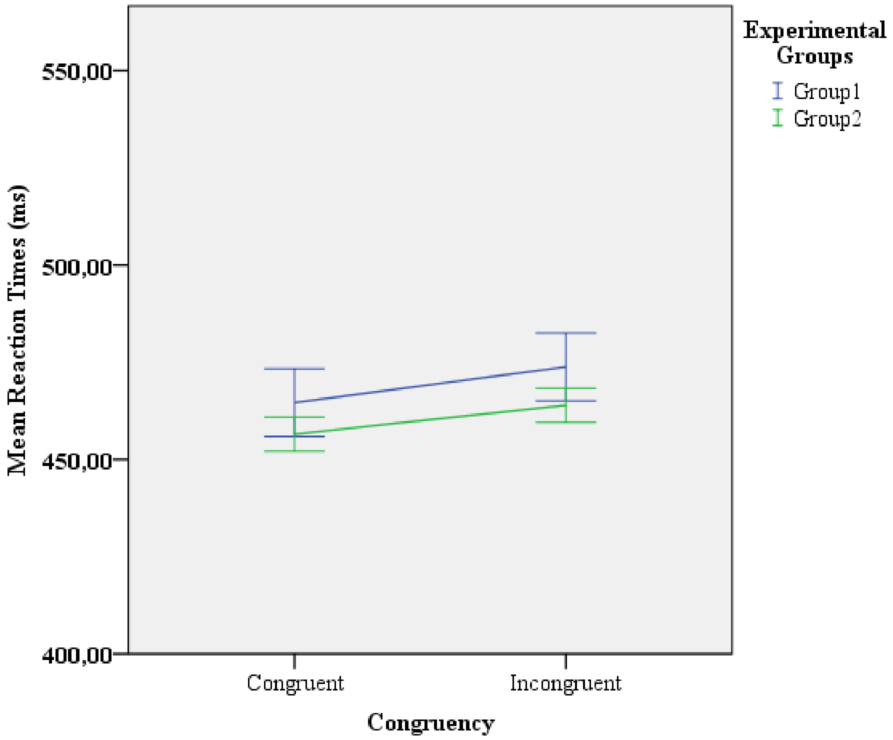

Figure 14 Experiment 7 Congruency Effects. Error bars represent SE. Note that effects are not statistically significant.

Discussion

The lack of any significant congruency effect in the second group, i.e. which was distracted away from the rule and told the rule at the end of the familiarization phase, is expected since this group did not have a chance to form strong enough short-term associations that would have had an influence in the later Simon phase. So, just telling the rule to the participants does not have the same effect as participants' becoming aware of the rule by themselves.

Yet, the lack of any congruency effect for the other group is more surprising, since the participants in this group were expected to form even stronger associations between the objects and movement directions as a result of the continuous repetition of the rule in the familiarization phase. One possible explanation of this finding is that it is the active seeking for (and finding of) the rule that enables the stronger short-term associations to be formed that at the end show their effects in the Simon phase if participant become aware.

It is also worth noting that, although these results do not seem consistent with the transfer studies where even just the instruction of a mapping rule shows its effects in a subsequent Simon task (as mentioned in Chapter 2.4) at first sight, Liefooghe et al.'s (2012, experiment 2) study shows that participants show the transfer effect only if they are prepared to respond later.

Overall, the results of this experiment indicate that explicit awareness of the rule is not sufficient for the subsequent effect in the Simon phase. Rather, the particular way that the awareness emerges, namely through active rule seeking and prediction, is also critical for the latter effect.

3.2.3. Experiment 8

Although receiving different instructions, all participants in experiment 6 were informed about the existence of the rule and asked to predict the rule throughout the familiarization phase. So, the learning that took place in that experiment was explicit (or intentional) learning. However, as the literature reviewed in Chapter 2.2 suggests, different ways of learning may give rise to different types of knowledge and behavioural effects.

In the following experiment, the participants were not informed about the existence of the rule so that any learning that presumably took place during the familiarization phase was implicit learning. The effects of this manipulation are expected to manifest themselves both in the awareness of the knowledge of the rule and in the later Simon phase.

Participants

14 students (7 male, 7 female, age range: 18-39 years) of Middle East Technical University participated in the experiment. All of the participants reported to have normal or corrected-to-normal vision.

Procedure

The stimuli and the presentation of the stimuli were identical with those in the previous experiment (i.e. Experiment 6). However, in the familiarization phase participants were not informed about the existence of the rule. Instead, they were instructed just to watch the presentation and try to memorize the color, shape and movement directions of the objects.

Results

The data was analyzed by a repeated measures ANOVA with congruency (congruent, incongruent trials) and blocks (9 blocks of 16 trials each) as within-subject variables. There was no significant effect of congruency. Figure 15 shows the congruency effect with standard errors.

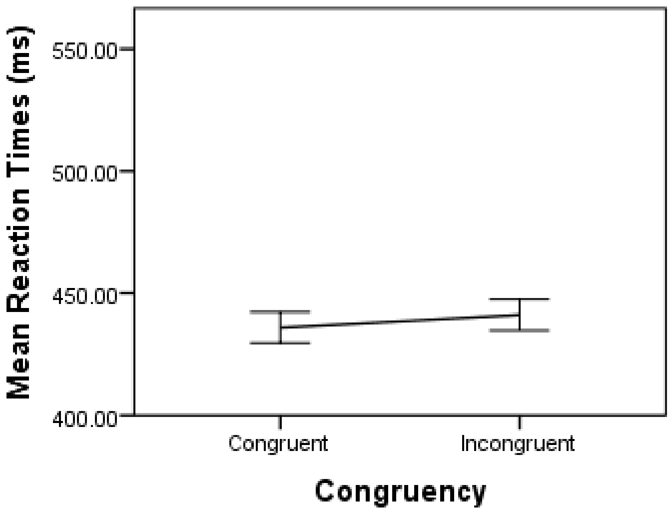

Figure 15 Experiment 8 Congruency Effect. Error bars represent SE. Note that the effect is not statistically significant.

The awareness of the participants of the rule in the familiarization phase was assessed via post-experimental interviews. A total number of 10 participants became aware of the rule. A t-test analysis for congruency conducted on these participants also did not reveal any significant effect.

Discussion

As a first point, it is important to note that 10 out of 14 participants became aware of the rule even though they had not been instructed about even the existence of the rule. This means most of the participants acquired explicit knowledge even under implicit learning instructions. This finding, although not predicted, is not totally surprising when one considers the explicit knowledge of the participants in the study of Gaujon et al. (2014) where the participants acquired the explicit knowledge of target locations in an implicit learning paradigm (i.e. contextual cuing). However, it is also possible that the participants looked for some regularity that would help them to memorize the instructed features, and since they were already directed towards the rule-relevant features (i.e. color, shape and also the movement direction) the extraction of the rule became an easy task for them That is, the learning that took place in the familiarization phase may have failed for the task to be a proper implicit learning task.

As stated in the results, there were no significant congruency effects, neither for all participants, nor for the aware participants. Once more, these results show that becoming aware of the rule is not sufficient for the subsequent Simon effect. However, different from Experiment 7, this time such a lack cannot be explained by the weakness of the short-term associations since the awareness of the rule emerged through the practice in the familiarization phase.

On the other hand, as different from Experiment 6, the familiarization phase of the present experiment did not include any prediction. Verbal predictions of the participants in Experiment 6 may be considered also as responses that were given in accordance with the stimuli. However, since the participants of the present experiment were instructed only to memorize the objects and the moving direction, there ass no similar response part in the familiarization phase. Accordingly, the lack of formation of the response codes (Hommel, 2011) can be taken as the reason of the absence of a congruency effect in the Simon phase.

Table 6 Summary of Results for Experiment 6, Experiment 7 and Experiment 8. Number of participants (*n*), mean response times and (standard error) for congruent and incongruent trials, mean congruency effect and (standard error), *t*-test values and significance values (*p*) for experimental groups.

Experimental Group	**n**	**Congruent (ms)**	**Incongruent (ms)**	**Congruency Effect (ms)**	**t**	**p**
Experiment 6						
Color and Shape	15	488(24)	498(24)	10(3)	-2.6	.021
Border	13	455(18)	462(19)	7(8)	-0.86	.4
Control	13	509(16)	523(19)	14(7)	-1.93	.077
Post-Experimental						
Aware	20	491(19)	502(20)	12(5)	-2.39	.027
Unaware/ Above Chance	13	472(19)	486(22)	14(7)	-1.89	.082
Unaware/Below Chance	8	489(24)	491(25)	2(9)	-0.22	.83
Experiment 7						
Group1 (Repeat the rule in familiarization phase)	15	464(17)	473(21)	9(8)	-1.05	.31
Group2 (Told the rule at the end of the familiarization phase)	15	456(11)	463(12)	7(4)	-1.68	.11
Experiment 8						
Implicit Learning	14	480(12)	486(15)	5(6)	-0.80	.43

CHAPTER 4

GENERAL DISCUSSION

The present study aims to investigate the behavioural effects of consciousness. To this aim a new experimental design is developed based on a previous study of Eren and Hohenberger (2009). In this design participants are expected to learn a rule that is presented to them in an initial phase, i.e. familiarization phase, and then they are transferred to a 2-choice stimulus response task, i.e. a Simon task.

One important merit of the final design is that it allows for a controlled manipulation of consciousness. In most of the studies in the literature, participants either never become consciousness of a rule, or are grouped as conscious or unconscious post-experimentally. The manipulation in the present study is provided by either directing the attention of the participants to rule-relevant features (i.e. color and shape), or distracting their attention away from these features. As in line with the concept of attention as an access mechanism to consciousness (e.g. Baars, 1997), participants whose attention is directed to the rule-relevant features become conscious of the rule, and those whose attention is distracted away from them remain unconscious. Furthermore, the participants in the control group that does not receive such a manipulation may or may not become conscious.

The findings of the study show that the short-term associations formed as a result of learning the rule in the initial phase influence the performance in the subsequent phase, i.e. the Simon phase. Moreover, the presence of this influence depends on the participants' consciousness of the rule. Furthermore, the results also suggest that consciousness of the rule is necessary but not sufficient for it to have a behavioural effect in the performance of the subsequent Simon task. In addition to the requirement of consciousness, it needs to be acquired through participants' own active rule seeking and predicting of the outcomes of the observed events during the rule learning phase. Only then can the stimulus features relevant in the rule transfer to and affect behavioural outcomes in a subsequent choice reaction task. The results of the present study support the relevance of action (outcomes) for consciousness as well as the relevance for consciousness for action. That action outcomes are relevant for consciousness is suggested by the finding that perceptual stimulus features (color, shape) got associated with spatial features (left, right movement) when participants tried to actively predict the movement direction in the rule-learning phase. That consciousness is relevant for action is suggested by the finding that those associated location features (left, right) learned in the familiarization phase and being explicitly available in participants' active working memory, acted as irrelevant spatial stimulus features and interfered with relevant stimulus features (inside patterns) in the Simon task, producing a standard Simon effect.

In Experiment 6, participants were instructed about the existence of a rule – but not which rule – and were asked to predict the rule in the familiarization phase. The short-term associations formed in this phase influenced the performance in the subsequent Simon phase as revealed by the significant congruency effect. Moreover, this effect was significant only for the group that had been directed to the rule-relevant features, and hence became aware of the rule.

The dissociation between verbal reports and prediction performance in this experiment is also important. Although all groups were above chance in the accuracy of their predictions, only the Color and Shape group showed a congruency effect in the subsequent Simon phase. In one respect this finding is in line with the remark of Merikle et al. (2001) quoted in the literature review that the performance in objective measures can be, at least partially, due to implicit processes.

Furthermore, as can be seen from Table 6, when participants are grouped with respect to their awareness of the rule and prediction performance, unaware participants who shows an above chance prediction performance tend to show a congruency effect. However, such a tendency is not present for the unaware participants who have a below chance prediction performance. This result, as consistent with a graded view of consciousness (e.g. Cleeremans, 2006), suggests that the effects of being conscious and unconscious are not mutually exclusive but rather consciousness is necessary for an effect to be stable and consistently transferable to different domains.

In order to elucidate the role of consciousness further, another experiment was conducted (Experiment 7) to investigate whether conscious knowledge of the rule was sufficient for the effect in the Simon phase – irrespective of the way it was acquired. In this experiment, participants were directly told the rule either at the beginning or at the end of the familiarization phase. The group that was told the rule at the end of the familiarization phase, was also distracted away from finding the rule throughout this phase. On the other hand, the other group was instructed to repeat the rule and predict the outcome. There was no congruency effect for either group. These results suggest that conscious knowledge alone without the formation of strong short-term associations between perceptual stimulus features and action features in the rule-learning phase does not give rise to a congruency effect. However, this is expected since the Simon effect is the result of the activation of differential spatial response pathways. So, if the short-term associations cannot be formed between the rule-relevant stimulus features and the movement direction in the familiarization phase, there cannot be any spatial response activation by these features in the subsequent Simon phase.

In Experiment 8, participants were not informed about the existence of the rule but instructed just to memorize the rule-relevant features and movement direction of the objects. Although most of the participants in this experiment become aware of the rule, there was no congruency effect in the Simon phase. Awareness of the rule indicates that short-term associations between the rule-relevant features and the movement direction are formed in the familiarization phase. However, participants in this experiment were not required to make any prediction in the familiarization phase. Thus, active prediction plays a key role in the formation of the spatial perception and action codes. The predictions in the familiarization phase of Experiment 6 can also be seen as responses. In other words, when participants predicted the movement of the object, they acted, or, simulated the event. This means that not only short-term associations between the rule-relevant features and movement direction were formed, but also corresponding response pathways were activated. Yet, in Experiment 8, since there was no prediction there was no activation of response pathways.

These findings suggest that consciousness of the rule is not sufficient for the subsequent behavioural effect in the Simon phase. To have an effect on the subsequent Simon task, consciousness of the rule must emerge through the active seeking of the rule that enables the formation of short-term associations between the rule-relevant features and response codes corresponding to the movement directions.

Pilot Experiments

Several pilot experiments were conducted in the scope of the present study before finalizing the current design. A comparison of their results with respect to the manipulation of rule awareness in particular is worthwhile. However, it should be noted that the results of this discussion cannot be conclusive since there were several changes among them (i.e. changes of familiarization rule, stimuli or the display of the stimuli).

The basic motivation behind these pilot experiments was to provide a controlled manipulation of conscious knowledge of the rule. Table 7 shows the number of participants who became aware of the rule for each group in different experiments.

Table 7 Number of participants who became aware of the rule with respect to experimental groups.

Experiment	**Group**	**Unaware (*n*)**	**Aware (*n*)**
Experiment 1 Naming Instructions 1 Rule-relevant Feature 36 trials	Color	3	9
	Border	4	8
	Control	3	9
	All	10	26
Experiment 2 1 Rule-relevant Feature	1 Cycle (12 trials)	7	3
	2 Cycles (24 trials)	2	8
	3 Cycles (36 trials)	3	9
	All	12	20
Experiment 3 Naming Instructions 2 Rule-relevant Feature 48 trials	Color and Shape	5	4
	Border	10	0
	Control	6	3
	All	21	7
Experiment 4 Prediction Instructions 2 Rule-relevant Feature 40 trials	Color and Shape	3	7
	Border	6	1
	Control	9	1
	All	18	9
Experiment 6 Prediction Instructions 2 Rule-relevant Feature 64 trials	Color and Shape	1	14
	Border	13	0
	Control	7	6
	All	21	20
Experiment 8 Implicit Learning 64 trials	Color, Shape, Movement Direction	4	10

As a first point it should be noted that participants in Experiments 1-3 were not informed about the existence of the rule. So, the learning that took place in these experiments is under implicit learning instructions. Independent of experimental group, most of the participants in Experiment 1 became aware of the rule. This suggests that if the rule is a simple one depending on just one feature of the stimuli participants become aware of the rule even when they are distracted away from the relevant feature. So, directing attention even to an irrelevant feature cannot prevent the extraction of the rule even with implicit learning instructions. On the other hand, the results of Experiment 3 suggest that increasing the number of rule-relevant features hinders becoming aware of the rule even if participants are directed to the rule-relevant features. Participants in Experiment 4 were informed about the existence of the rule and asked to predict it, i.e. they received explicit learning instructions. When compared to Experiment 3, results show that explicit learning instructions enable becoming aware of the rule only for the participants that are directed towards the rule-relevant features. Experiment 6 shows that increasing the number of instances – at least in the observed range – does not affect the awareness of the group that is distracted away from the rule. In Experiment 8, participants were not informed about the existence of the rule. However, in this experiment they were not only directed towards the rule-relevant features, but also to the movement direction. So, in contrast to the participants in Experiment 3, they became aware of the rule.

It is also worth noting that, although most of the participants in Experiment 1 and Experiment 2 became aware of the rule, there was no significant congruency effect in the Simon phases of these experiments. However, similar to Experiment 8, instructions in the familiarization phases of these experiments did not require any prediction. Hence, consistent with the result of Experiment 8, the associations between the rule-relevant features and response codes that are required to influence the performance in the Simon phase could not be formed.

Another point that must be mentioned is the difference between the results of the Simon phase in Experiment 4 and Experiment 6. Although participants in both experiments received the same instructions in the familiarization phase, there was no significant congruency effect for the color and shape group in Experiment 4 but data trends showed a heterogeneous distribution of reverse and normal congruency effects for this group. One may speculate that the movement of the object in the familiarization phase of the previous design (Experiment 4) may have caused an ambiguity since they were not directly moving to the left and the right, but rather moved diagonally towards these sides. Note that we took the familiarization phase over from the previous study of Eren and Hohenberger (2009) which was about the effects of “affordances” of objects. Therefore there were two objects, where the affordance of the first was to induce a movement of the second to the left or right. Across the course of experiments in the present study, we abandoned the first design with the additional object, the triangle, and the ambiguous diagonal motion and retained only the relevant properties of the familiarization phase: the perceptual features of the object and their movement direction. Also, the unexpected effect of the horizontal and vertical inside pattern and response direction interaction in the previous Experiment 4, as shown by Experiment 5, might have interfered with the congruency effect.

Consciousness

The assessment of consciousness in the present study is *via* verbal reports. As stated in the Literature chapter, verbal reports of the participants are taken as indicators of their subjective experience. Although at this stage it cannot be claimed that the present study directly tackles the hard problem of consciousness, the results show that the experimental design developed in the scope of the study can be used to investigate differences in the behavioral performance accompanied by certain subjective experience.

The important difference of the present study from most of the empirical studies of consciousness is that the experimental design developed in its scope enables investigating the effects of both conscious and unconscious knowledge. In line with most of the empirical studies of consciousness it reveals the effect of unconscious knowledge in the performance as indicated by the above-chance prediction performance even of participants who are unaware of the rule. However, different from the other studies, the results also reveal the behavioral difference that consciousness makes. That is, consciousness is necessary for this knowledge to influence the performance in another task.

It is worth noting that most of the implicit learning paradigms also employ a similar structure where there are two phases, i.e. the training and the test phase. What these paradigms show is that unconscious knowledge acquired in the training phase has an influence on the test phase. However, different from the present study, the relation between the two phases is evident for the participants. In the present study, however, none of the participants ever became aware of the relation between the rule-learning phase and the Simon phase.

Although the results suggest that consciousness is necessary for the behavioural effect in the subsequent task, they also show that the presence of this effect depends on other constraints. For example, in the scope of present study, conscious knowledge of the rule must be acquired to have an effect on the subsequent behavior of the participants. However, this knowledge cannot just be declarative knowledge being passively represented but must have been acquired in an action-based or simulation-based way. Moreover, this effect is present even when participants are not aware of the relation (where the features that influence their actions come from) and of the mechanism.

Future Studies

In this section some additional experiments are suggested with the aim of generalizing the results beyond the current findings in the scope of this thesis. The rule in the familiarization phase of the present study is dependent on the relation between the movement direction and the color and shape features of the objects. As being an action feature of the objects, movements may play a special role in the formation of response (action) codes that are effective in the subsequent Simon phase. That is, perception of the action of an object may be accompanied by the simulation of the relevant action and may result in a stronger association between the object and the corresponding motor action as when the movement was missing. To investigate this possibility, an experiment with the same design of Experiment 6 but a slightly different familiarization phase can be conducted where the objects in the familiarization phase will be presented on the sides (i.e. left or right) of the screen without any movement. In such a design the associations that are expected to influence the behaviour in the Simon task will be formed between a static spatial feature (i.e. location) and the rule relevant features of the objects. If action perception has the assumed additional effect on the associations formed in the familiarization phase, then a smaller congruency effect will be observed in the Simon phase.

The spatial Stroop task is another perceptual-motor control task where a stimulus has two different spatial features (e.g. the word ‘LEFT’ presented at the right or left side of a screen) one of which is relevant for the response to be given (e.g. responses are to be in accordance with the meaning of the word) and the other one is irrelevant for the response (e.g. the location of the word). As similar to the Simon effect it is observed that responses are faster for the trials when the irrelevant spatial feature is congruent with the response (and also with the other spatial feature), than when it is not (see Lu and Proctor 1995 for a review). Although, the underlying mechanisms of the spatial Stroop task and Simon task are considered as different due to the arbitrary mapping of the response-relevant feature in the Simon task (Kornblum et al., 1990; Hommel, 2011), there are also proposals for a common mechanism underlying both effects (Lu and Proctor, 1995). The experimental design of the present study allows a comparison of these effects. For this comparison the familiarization phase will remain identical but the stimuli in the subsequent phase will be presented at the right or left of the screen, and the participants are told to give left or right responses corresponding to the position of the stimuli (i.e. press left for the stimuli that appear at the left of the screen). In such a case, congruent trials are the ones where the movement direction of the stimuli in the familiarization phase is the same as the position of the stimuli in the subsequent Stroop phase. Figure 16 shows examples of congruent and incongruent stimuli of such a design. The resulting pattern of the congruency effects is expected to be similar if the spatial Stroop task and the Simon task have the same underlying mechanisms.

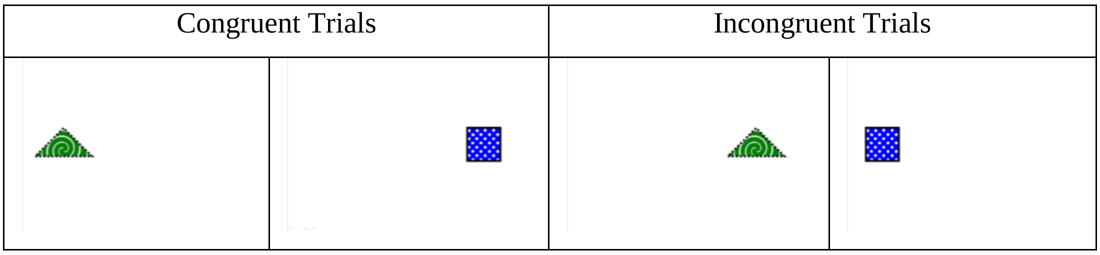

Figure 16: Future Study Stroop Phase Stimuli. Examples of congruent and incongruent trials of the spatial Stroop phase when the participants are to give left reponses to the stimuli at the left and right responses to the stimuli at the right (and when green triangles moves to the left and blue squares moves to the right in the familiarization phase).

Although the stimuli in the familiarization phase and the Simon phase were different in some of the pilot experiments, they are identical in the final design. However, since this is not the only change on the way to the final design, one may still wonder whether the observed Simon effect depends on associations between the objects and their action features when objects remain identical, or whether the associations can also be formed more abstractly between just the rule-relevant features and the action feature while other, irrelevant features may change. The Simon effect is usually claimed to hold on the level of object features. However, object identity might be an additional factor that facilitates feature association. Put negatively, changing object identity by changing irrelevant object features (while preserving the identity of the rule-relevant features) might interfere with retrieving previously formed associations with relevant features. To test this latter possibility the current experimental design can be conducted with a Simon phase where the rule-irrelevant features of the stimuli are different from the familiarization phase stimuli (e.g. green triangles and blue squares with different border and inside patterns). Note that such an abstraction may affect participants who become aware of the rule and those who do not become aware but have an above-chance prediction performance differently.

Lastly, an additional experiment may tap the relation between the two phases of the experiments. As mentioned above the participants are never told the relation between the two phases of the experiments and they never become aware of such a relation.

One may speculate that if they are told about the relation between these two phases explicitly the behavioural effect observed in the Simon phase may change due to the participants having a kind of higher-order awareness. That is, they do not only become aware of the rule between the stimulus features, but also will be aware of the effects that this rule may have on their behaviour in the second phase. In such a case the observed Simon effect may change due to the strategies that participants can adopt in the face of this additional knowledge.

Limitations

Although the Simon effect is a robust phenomenon that requires only between ten to fifteen participants to obtain a significant effect, the smaller effect observed in the transfer studies in the Simon paradigm usually require more participants (e.g. there were almost thirty participants in post-experimental groups in Vu's 2011 study, and twenty participants in experimental groups in Pellicano et al.'s 2008 study). This is understandable due to the fact that the associations between the irrelevant feature of the stimuli (i.e. position) and the response direction in a traditional Simon task are considered as long-term associations formed through everyday experience over a life-time. However, the associations formed in the course of a transfer experiment are expected to have a weaker effect. Accordingly, replicating the present experiments with more participants may be required to be able to get more robust results. Increasing the number of participants may be critical in particular for the group of participants who did not become aware of the rule but showed above-chance performance.

Also, as stated in the method sections of the relevant experiments, the participants of the present experiments are from different universities of Turkey. Such a difference may also have an uncontrollable effect on the results.

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APPENDIX

ETHICAL CLEARANCE

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Danışmanlığını yapmış olduğunuz Bilişsel Bilimler bölümü doktora öğrencisi Selvi Elif Gök'ün "**Bilincin Eylemlere Davranışsal İlgisi: Simon Testi Kullanarak İncelemeler**" isimli araştırması "İnsan Araştırmaları Komitesi'' tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

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