Suggestion adds an edge to automaticity: measuring, elucidating, and understanding positive hypnotic hallucinations

Noémie Aubert Bonn

Department of Psychiatry, Faculty of Medicine

McGill University, Montréal

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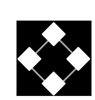
Abstract

A visual variation of the abstract is available in an interactive video format at razlab.mcgill.ca/thesis_aubertbonn.html[*].

Once automatized, cognitive processes seldom return to the purview of control; when they do, however, this reversal happens with much difficulty. Inspired by recent evidence introducing the role of suggestion in de-automatization, the present thesis elucidates how hypnotic suggestion renders a difficult task more automatic without extensive practice. Using MoTraK, a task inspired by a documented visual illusion, we investigated whether a specific hypnotic suggestion to view non-existent visual cues would increase performance. Our results show that highly suggestible individuals (i.e., participants who are likely to respond to hypnotic suggestion), but not controls, improved their accuracy after receiving the suggestion. We discuss how these findings, beyond theoretical accounts of hypnosis and visual perception, hold potential clinical implications. In this regard, MoTraK may serve as a stepping stone in investigations concerning the regulation of mind and body through placebo responses/effects and top–down modulation.

Flip the pages rapidly to view the ODP with visible occluders in motion.



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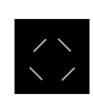
Résumé (french abstract)

Une vidéo interactive complémentaire à ce résumé est disponible sur le site Internet razlab.mcgill.ca/thesis_aubertbonn.html*.

Une fois automatisés, certains processus cognitifs retournent très difficilement au contrôle conscient. S'inspirant d'une branche de la recherche selon laquelle la suggestion peut faciliter la dé-automatisation de certains processus cognitifs, la présente thèse cherche à comprendre le rôle des suggestions hypnotiques dans l'automatisation des processus cognitifs difficiles. Nous avons utilisé MoTraK, une tâche basée sur une illusion visuelle documentée en recherche sur la perception, afin de déterminer si une suggestion hypnotique spécifique peut suffire à améliorer la performance sur cette tâche difficile. Nos résultats montrent que les individus hautement susceptibles aux suggestions ont, au contraire des individus non ou peu susceptibles, augmenté la justesse de leurs réponses après avoir reçu la suggestion. Nous établissons que les implications de nos résultats vont au-delà de la croissance des connaissances théoriques concernant l'hypnose et la perception visuelle et détiennent une valeur médicale et de potentielles applications cliniques. Suivant cet ordre d'idées, MoTraK peut servir d'outil pionnier dans l'exploration des interactions corps–esprit telles que l'effet placebo et les régulations descendantes (top–down).

Flip the pages rapidly to view the ODP with invisible occluders in motion



* Veuillez contacter Noémie Aubert Bonn, auteure de la présente thèse, afin d'obtenir un mot de passe vous permettant d'accéder à la vidéo : noemie.aubertbonn@mail.mcgill.ca

Acknowledgements

I would like to express my warmest appreciation to all the people who contributed to this thesis. First and foremost, I would like to thank my supervisor, Dr. Amir Raz, for his support, guidance and encouragement throughout, and beyond my Masters project.

I would also like to thank Alexandra (Hallie) Fischer who was my right hand (and, I would dare to say my right brain hemisphere as well) throughout the elaboration, analysis and interpretation of this project. Her organization, patience, and composure saved me many times and I cannot thank her enough for her help.

I sincerely thank Dr. Michael Posner and Dr. Erik Woody for their insightful comments on the ideas guiding my project and Jean-Roch Laurence who reviewed my initial submission

Given my limited experience with informatics, I gathered the precious help of a number of knowledgeable individuals when creating MoTraK. I would like to recognize Stian Reimers, Nikolai Loukine, Marc-André Dion, Kevin Bergeron, Tovorina Razakaria (IT services at McGill), Jeremy Cooperstock, and Guy Lifshitz for helping me build my Adobe® Flash® assessment tool, as well as Saverio Biunno and Chen Karako for helping me test MoTraK reaction time measurements with a photoelectric cell.

I extend my thanks to my precious lab members and friends who supported me and helped editing my thesis and ideas. A special mention to, Sheida Rabipour, Natasha Campbell, Claire Champigny, and Silka Freiesleben, for reviewing my thesis; Stephanie Lau, Erica Abbey, Galina Pogossova, Sabrina Ali, and Ilia Blinderman for their encouragements; Michael Lifshitz for his insights; and all of the RazLab for their patience and devotion.

Thanks to past researchers who inspired my questions, and thanks to future readers who may give meaning to, perpetuate and expand on my findings.

Et merci papa de m'avoir donné le courage et l'inspiration de me rendre jusqu'ici.

Preface & contribution of authors

In the present thesis, I describe my Masters project through a collection of manuscripts describing two distinct experiments that represent the focus of my Master's research. The first experiment describes the creation and validation of our tool, and the second aims to answer our core research question. Dr. Raz and I authored the first manuscript, *Assessing motion interpretation: further insights on the Occluded Diamond Paradigm,* which focuses on the task we developed to answer the overarching research question of the present project. While Dr. Raz contributed the idea behind using such a task, I built and developed the task, was principally responsible for collecting, analysing, and interpreting the data, and drafted the manuscript. The second manuscript, entitled: *Hypnotic suggestion enlightens missing information: an empirical study of hallucination,* focuses on the main findings presented in the present thesis and delves into the significance of these findings. The final manuscript, *Suggesting critical visual information transforms difficult into easy*, is a concise excerpt of the latter manuscript that we intend to publish as a short communication paper. Alexandra Fischer, Dr. Raz, and myself author both of these manuscripts. Dr. Raz supervised Miss Fischer and me, and proposed the core research idea; Miss Fischer and I collected, analysed, and interpreted the data.

Glossary

Below you may find a short glossary of some technical words employed in the present thesis. Throughout the thesis, a special font indicates that a specific technical word is accessible in the *Glossary*. Note that the definitions are tailored to the present thesis and may not represent the full meaning of an expression.

Apex
: The joint corner of a geometric figure; where two segments connect with one another.

Automatic process
: A process that is deeply ingrained and requires little or no attention. It is often fast and executed so easily that it may be described as outside of conscious control (cf., controlled process).

Bottom-up
: Process, perception, reaction, or physiological response triggered by internal or external stimuli (cf., top-down).

Controlled process
: A process that is not automatic (see automatic process), that is often slow, effortful, and requires much attentional energy.

Demand characteristics
: An experimental situation in which participants responses or behaviour are influenced by their interpretation of the research purpose. Typically considered as confounding variables, demand characteristics constitute an important artefact in psychological research, especially in research that relies on participant reports.

Hallucination
: We will adopt the definition brought up by Slade and Bentall in which a hallucination corresponds to "any percept-like experience which (a) occurs in the absence of an appropriate stimulus, (b) has the full force or impact of the corresponding actual (real) perception and (c) is not amenable to direct and voluntary control by the experiencer" (1988, pp. 23).

Hallucinator
: In the present thesis, I will use the term *hallucinator* to refer to a highly hypnotizable individual who has the ability to hallucinate or perceive his or her own internal, mental events as if they originated from external events.

Holdback effect

Particular to hypnosis studies, holdback effect refers to a situation in which a participant refrain from performing optimally in a pre-assessment to leave room from improvement in the post-assessment with hypnosis (Zamansky, Scharf, & Brightbill, 1964).

Hypnosis

Hypnosis can be characterized as a state of altered consciousness in which the hypnotized individual reaches attentive–receptive concentration and is more responsive to suggestion (Oakley & Halligan, 2009; Raz & Shapiro, 2002).

Hypnotic suggestion

A suggestion that occurs within a hypnotic context (see suggestion). Specifically, a hypnotic suggestion is a phrase or instruction said during hypnosis and that is meant to modulate the thoughts, behaviours, or perceptions of an individual.

Negative hypnotic hallucination

A negative hallucination (cf., positive hypnotic hallucination) that occurs as a result of hypnotic or post-hypnotic suggestion. When we talk of negative hallucinations, we mean a particular hallucination that *removes* elements from the perception of the hallucinator even though the elements are present in reality (e.g., hypnotic analgesia).

Negative priming

Negative priming occurs when participants respond slower in a trial in which the ink colour corresponds to the word ignored in the preceding trial (e.g., participants will take longer to determine the ink colour of the word RED written in blue ink if they just answered a trial in which the word BLUE was written in green ink; Mayr & Buchner, 2007). Because participants ignored the colour word (e.g., BLUE) in the preceding trial, it takes them more time to access the ink colour (e.g., which is also blue).

Occluder

Mask occluding parts of a moving figure. In this thesis, occluder refers to a static shape covering the apex of a moving geometric figure. The occluder can be visible — outlined, or filled with a colour that differs from the background — or invisible — with its contour and colour matching the colour of the background. In the current thesis, we sometimes refer to *visible occluders* and *invisible occluders*, but also sometimes refer to *occluded* and *non-occluded* trials, respectively. These terms should be considered interchangeable.

Optokinetic drum

An optokinetic drum is a rotating instrument used in visual research. It consists of a three-dimensional cylinder with its flat planes facing top and bottom. The cylinder is striped vertically; when it rotates, the stripes move in the direction of the rotation (to the left or to the right). When observers look at the rotating drum, their eyes smoothly follow the stripes until they reach the edge of their visual field. Observers then re-center their gaze with a quick saccade and repeat the movements. Researchers term this looping pursuit and saccade movement visual *nystagmus*.

Performance

Combination of *reaction time* and *accuracy*. A better performance involves faster reaction times and higher accuracies.

Positive hypnotic hallucination

A positive hallucination (cf., negative hypnotic hallucination) that occurs as a result of hypnotic or post-hypnotic suggestion. When we talk of positive hallucinations, we mean a particular hallucination that *adds* elements to the perception of the hallucinator even though the elements are absent from reality (e.g., hallucinating colours on a black and white picture).

Post-hypnotic suggestion

A suggestion given under hypnosis, but that is put in action after the participant is brought back under a normal state of wakefulness.

Revolution

A movement characterized by a circular translation, occurring on a two-dimensional plane.

Stroop interference effect

In the Stroop task, participants need to identify the ink colour of a displayed word (Stroop, 1935). When identifying the ink colour of an incompatible colour word (e.g., the word "BLUE" displayed in green ink), subjects tend to be slower and less accurate than when identifying the ink colour of a neutral word (e.g., the word "LOT" printed in red). The difference in performance between control trials and conflicting trials is called the Stroop interference effect.

Suggestion

Suggestion generally refers to a verbal phrase enunciated within or outside of hypnosis, and intended at eliciting perceptual, emotional, cognitive or motor changes in an individual (Kihlstrom, 2008).

Top-down

Processes triggered by the influence of higher cognitive functions on lower perceptual or physiological functions (cf., bottom-up).

Vividness (of a hallucination)

Perceived reality attributed to a hallucination. This subjective notion refers to the resemblance the hallucination shares with a real, stimulus-triggered, perception.

Yedasentience

"From the Hebrew *yeda*, knowing, and Latin *sentire*, to feel; an internally generated feeling of knowing" (Erik Woody & Szechtman, 2011, pp. 8).

Thesis introduction, objectives, and rationale

The fundamental idea behind my Master's Project was to test whether a hypnotic suggestion could transform a difficult task into an easy one.

Cognitive neuroscientists typically differentiate between controlled and automatic mental processes. They often characterize controlled processes as being slow, difficult, and requiring much attentional energy. On the other hand, they often define automatic processes as being fast, substantially easy, and requiring little or no attentional effort. Controlled processes can become automatic after extensive exposure or practice (MacLeod & Dunbar, 1988; Spelke, Hirst, & Neisser, 1976). For example, a child who is just learning to differentiate letters and for whom reading is a tenuous and difficult task, will often become an experienced reader after a few years of education and be able to read effortlessly even while attending to other aspects of the environment. Most interestingly, once reading becomes automatic, a proficient reader will exhibit difficulty refraining from reading words that appear before his eyes (Shiffrin & Schneider, 1977). Scientists have shown the automaticity of reading using cognitive tasks such as the Stroop task (Stroop, 1935). In the Stroop task, an experimenter presents words written in a specific ink colour to the participants. The task of the participant is to identify, as fast as possible, the colour of the ink. In some trials, the written word is a colour word (e.g., BLUE, RED, GREEN), while in other trials, it is a neutral word (e.g., LOT, FLOWER). When attempting to name the ink colour of a colour word, many participants incorrectly report the written word or take longer to answer when the word and the ink colour differ (e.g., the word BLUE written in green ink) than when the word displayed is neutral (e.g., the word "FLOWER" displayed in blue ink). This effect is referred to as the Stroop interference effect (MacLeod, 1991). This line of research illustrates the robustness of automatic processes and intimates how difficult it is to bring such processes back to conscious control.

In the past decade, several studies have challenged the automaticity of the Stroop effect, suggesting that diverse mechanisms, such as attention, memory, and emotions, may differentially affect how one responds to the Stroop task (Besner, 2001; Besner & Stolz, 1999; Dishon-Berkovits & Algom, 2000; Kuhl & Kazén, 1999; Long & Prat, 2002; Sharma, Booth, Brown, & Huguet, 2010). Keeping this idea in mind, Raz and colleagues investigated the potential influence of suggestion, administered with (e.g., Raz, Fan, & Posner, 2005) and without hypnosis (e.g., Raz, Kirsch, Pollard, & Nitkin-kaner, 2006), on the modulation of the Stroop interference effect. Suggestion is particularly interesting to scientists as it can elicit, in certain individuals — for example highly hypnotizable individuals (HSIs) — behaviours or perceptions that are otherwise difficult, if not impossible, to reproduce. Using hypnotic (Raz et al., 2005; Raz, Shapiro, Fan, & Posner, 2002), post-hypnotic (Raz et al., 2003), and non-hypnotic (Raz, Kirsch, et al., 2006; Raz, Moreno-Iñiguez, Martin, & Zhu, 2007) suggestions to disrupt the semantic processing of written words, Raz and colleagues probed the possibility of de-automatizing reading. Findings from this new line of research propose that specific hypnotic suggestion to view the words as semantically incomprehensible (e.g., interpreting the words as if they were written in a foreign language and represented meaningless symbols) may reduce (see Lifshitz, Aubert-Bonn, Fischer, Kashem, & Raz, 2012 for a review of our own studies and independent replications) or even eliminate (where "eliminate" loosely refers to the absence of statistical difference between neutral and incongruent trials; Raz et al., 2003; Raz et al., 2002) the Stroop interference effect in HSIs. In other words, hypnotic suggestion helped HSIs regain control over the largely automatic process of reading (Lifshitz, Aubert-Bonn, et al., 2012; Raz et al., 2003).

Following this research trend, the present thesis examines the modulation of automaticity from a different angle and poses the following research question: "Can a specific hypnotic suggestion go in the opposite direction and transform a difficult task into a more automatic one without extensive practice"?

Connecting Ideas: Manuscript One

Manuscript One describes the task I developed to test the idea behind my research project. As I explain in the following manuscript, we used the Occluded Diamond Paradigm (ODP) — a visual illusion first introduced in the 1980s and subsequently documented in research on visual perception — to probe the role of hypnotic suggestion on the modulation of automaticity. In the ODP, it is very difficult to determine the direction of motion of a simple, partially occluded geometric figure moving circularly on a two-dimensional plane. Determining the direction of motion becomes easy, however, when we introduce simple visual cues.

Inspired by the ODP, we developed MoTraK, an online assessment consisting of a series of adaptations of ODP-like paradigms in which response time and accuracy are measured. This first manuscript details the average performance and modulators of MoTraK.

The novelty of MoTraK was both a great asset and a limitation to our study. Given that very few researchers documented the ODP and that none used MoTraK, the conclusions we could draw from our study were limited. Nonetheless, the novelty of MoTraK was advantageous in the following three ways: i) having both developed and studied MoTraK, we are intimately familiar with the task and were able to optimize it to meet our specific research needs; ii) MoTraK allowed us to answer a question that was otherwise difficult to elucidate without relying on participant reports (i.e., the perception of hypnotic hallucinations); and iii) we documented average performance on MoTraK with the same population we used to answer our empirical question (Manuscript Two), thereby maximizing reliability.

Manuscript One

Assessing motion interpretation: further insights on the Occluded Diamond Paradigm

Noémie Aubert Bonn*, & Amir Raz*

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*Department of Psychiatry, McGill University, Montreal, QC, H3W 1E4, Canada

Abstract

Despite its sophistication, the human visual system can be tricked by simple visual illusions. Beyond helping perceptual neuroscientists understand visual processing, ambiguous visual phenomena, such as visual hallucinations, may help cognitive neuroscience better understand visual perception and its modulators. In the present investigation, we document MoTraK — a unique visual task we developed using a visual illusion model known as the Occluded Diamond Paradigm (ODP). In the ODP, determining the direction of motion of a partially occluded two-dimensional geometrical shape is difficult. When visual cues are visible, however, determining the direction of motion becomes effortless. Our study revealed that accuracy does not increase with practice and that performance on MoTraK does not seem to rely on any streamline strategy. MoTraK, therefore, seems well suited for future cognitive investigation, especially for elucidating how visual hallucinations can facilitate the automatization of effortful processes.

Keywords: *Occluded Diamond Paradigm; visual illusion; MoTraK; motion perception; visual hallucination*

Introduction

When observing an object moving behind a grid (Figure 1A) it is clear to us that the object remains complete despite its image being sectioned in several segments in our retina (Figure 1B as opposed to Figure 1C). Perception researchers explain this preservation of object unity with the Gestalt motion binding principle (or law of common fate), stating that we tend to bind visual elements that are moving in the same direction into a whole and perceive them as undergoing a full coherent motion despite possible discontinuities of the object (Koffka, 1935).

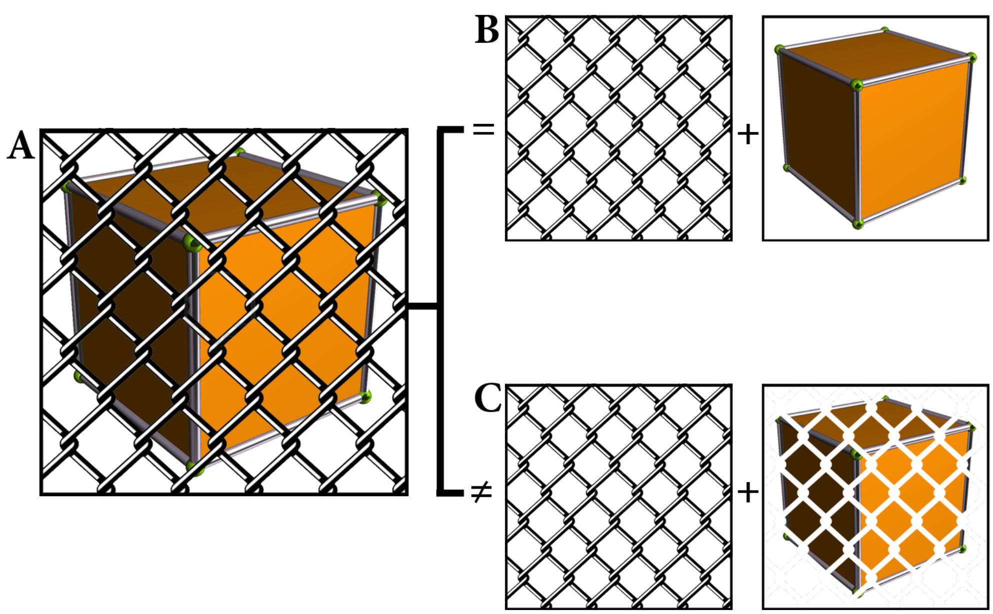

Figure 1. *Gestalt motion binding principle.* When looking at an object that is partially hidden by a grid (A), our perceptual system fills in the missing information and we understand that the partially occluded object is a whole (B), rather than cut into pieces by the occlusion (C).

In other cases, however, removing a parcel of information suffices to completely disrupt the processing of a visual scene. A good example of such a phenomenon is the Occluded Diamond Paradigm (ODP; Lorenceau & Shiffrar, 1992), in which the visibility — or invisibility — of simple visual masks governs the perception of motion.

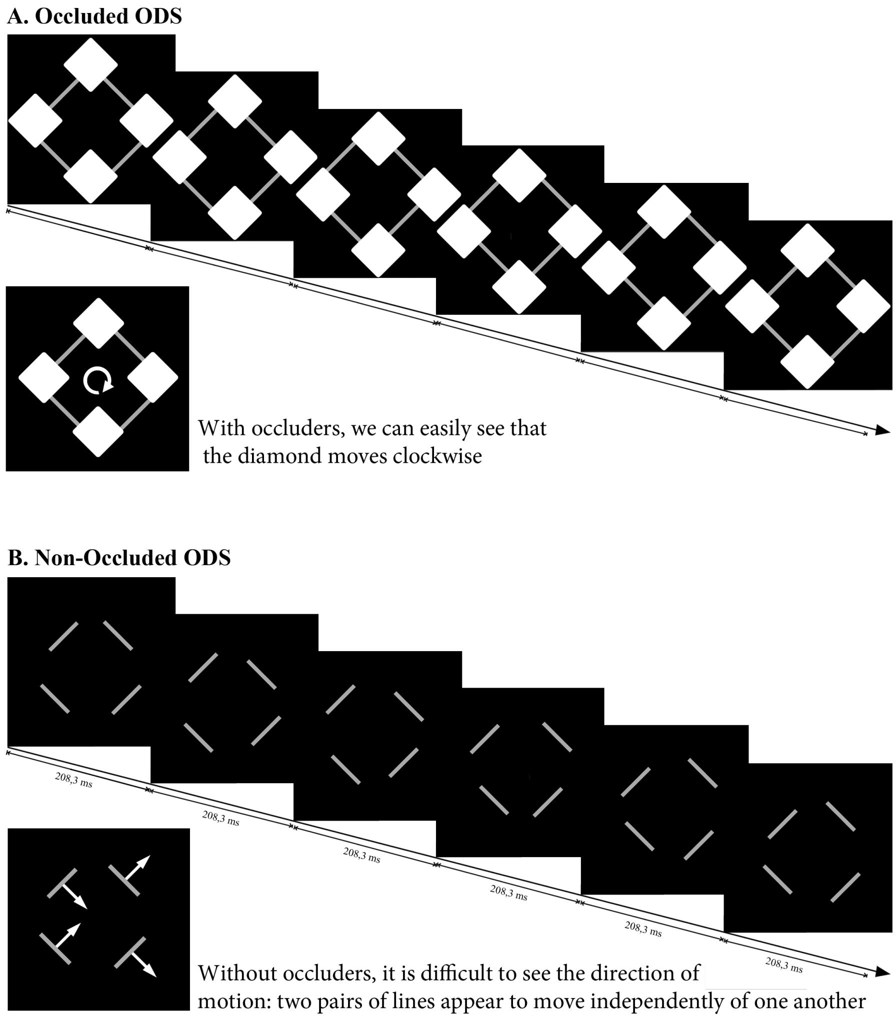

Figure 2. *The visibility of occluders.* When occluders are visible (A), determining the direction of motion is easy. When the occluders are invisible by matching the colour of the background (B) determining the direction of motion is difficult.

The Occluded Diamond Paradigm

In the Occluded Diamond Paradigm illusion, a grey outline of a square moves in a circle, either clockwise or counter-clockwise, over a static monochrome background. Each corner of the square is covered by a smaller static square (referred to as an occluder) that is either visible (i.e., traced or filled with a colour that differs from that of the background), or invisible (i.e., outlined and filled with a colour that matches the colour of the background). When the occluders are visible, it is easy to determine the direction of motion (clockwise or counter-clockwise) of the revolving square (see Figure 2A). When the occluders are invisible, however, determining the direction of motion becomes difficult (see Figure 2B).

As the visual contrast between the occluders and the background decreases, and as the occluders become less salient, motion perception becomes increasingly difficult and most observers declare seeing a "jumbled mess of four moving segments" rather than a revolving square when the occluders completely match the colour of the background (Lorenceau & Shiffrar, 1999, pp. 433). Shimojo (1989) explains this disjunction as resulting from intrinsic and extrinsic perception of boundaries. When the occluding objects are visible (Figure 3A), the discontinuous geometrical outlined shape (in this case the revolving square) appears to be moving *behind* the occluding objects and the observer interprets the boundaries of the occluded object (i.e., the contact area between the occluders and the revolving square) as *extrinsic*, belonging to the occluders rather than belonging to the revolving square. Therefore, by considering the boundaries *extrinsic* to the revolving square, the observer interprets it as a single, united object that is partially hidden but nonetheless preserves the Gestalt motion binding principle (Figure 3B). Conversely, when the occluding objects are invisible (Figure 3C), there is no visual representation of the occlusion and the observer considers the boundaries of the partially hidden object (i.e.: the revolving square) to be *intrinsic* boundaries, belonging to the revolving square itself. The object thus appears to be divided into several segments (Figure 3D) rather than simply hidden behind occluders.

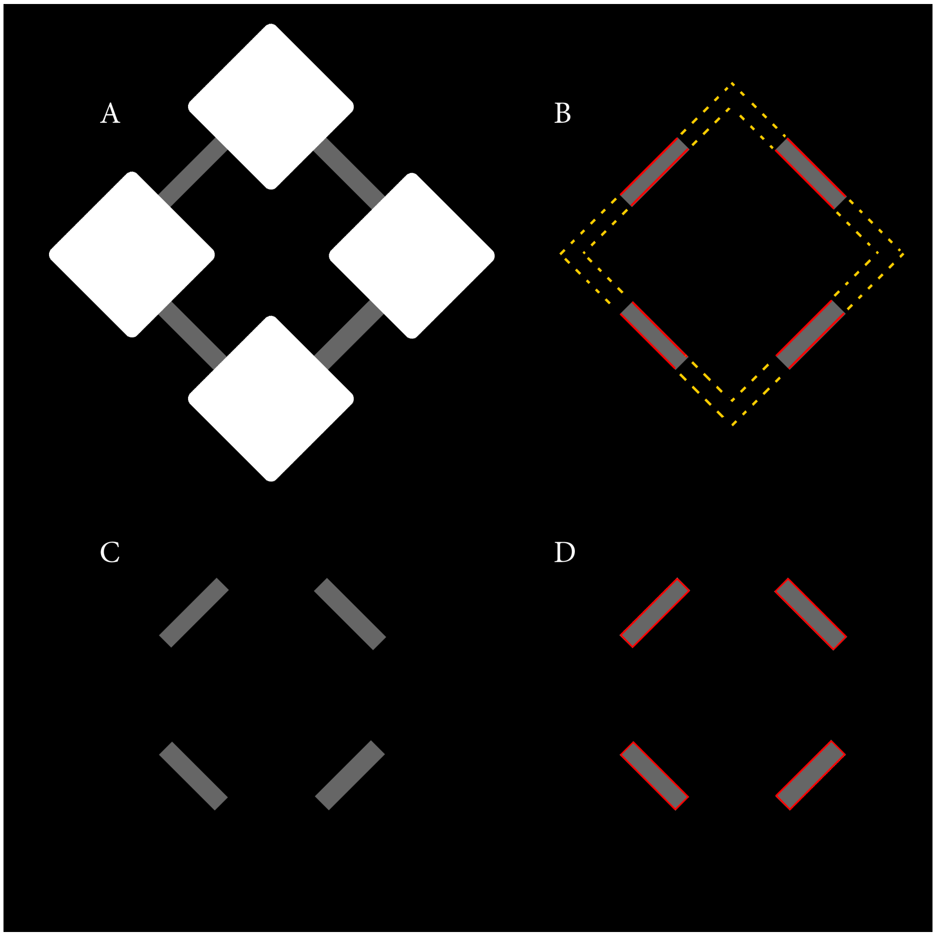

Figure 3. *Intrinsic* boundaries of the revolving diamond are traced in red (B and D). When occluders are visible (A), the observer interprets the boundaries between the occluders and the moving diamond as *extrinsic* to the diamond (B). In this case, the revolving square appears to be moving behind the occluders and therefore preserves its perceived unity (yellow dashed lines represent the perceived figure [B]). When the occluders are invisible however (C), the observer perceives the boundaries between the occluders and the moving diamond as *intrinsic* boundaries of the diamond (D), thereby perceiving the hidden shape as a series of separate segments.

De-automatization

The illusory effect triggered by the ODP is very strong (see razlab.mcgill.ca/thesis_odp_aubertbonn.html for a short video of the ODP) as it appeals to perceptual processes that lie largely outside our conscious control (Treisman, 1985). In the field of behavioural neuroscience, such tasks allow researchers to identify the particular perceptual capacities of specific individuals or situations. In research on hypnosis, for example, researchers need to test the effects of suggestion using a task that cannot be influenced by abilities, volition, practice, or social compliance to determine whether a visual hallucination or perceptual modulation genuinely disrupts perception. As a result, hypnotic researchers have used broadly documented, robust tasks such as the Stroop (e.g., Raz et al., 2002), the flanker (e.g., Iani, Ricci, Gherri, & Rubichi, 2006), or the McGurk (e.g., Lifshitz, Howells, & Raz, 2012). In the Stroop task (MacLeod, 1991; Stroop, 1935), participants must indicate the ink colour of several words, some of which are colour words. Generally, the semantic meaning of a colour word will override the ink colour detection, making participants perform slower and less accurately when a colour word is presented with a conflicting ink colour (e.g., the word BLUE in red ink). In the flanker task (Kopp, Mattler, & Rist, 1994), participants have to determine the direction of a target arrow surrounded by distractor arrows. The distractors may be congruent — pointing to the same direction as the target arrow — or incongruent — pointing to a different direction. As in the Stroop task, participants are slower and less accurate with incongruent stimuli. In the McGurk task (McGurk & MacDonald, 1976), a video of a mouth articulating a syllable is paired with the audio recording of a syllable. The recording and the video may either be congruent — both saying the same syllable — or incongruent — enunciating different syllables. In the latter case, the syllable perceived by the participant is often a mixture of both syllables (e.g., visual /ga/ and auditory /ba/ may be perceived as /da/ by the participant). The advantage in using these tasks stems from the fact that they draw on processes that are deeply entrenched and that lie largely outside of our conscious control (Iani, Ricci, Baroni, & Rubichi, 2009; MacLeod, 1991; McGurk & MacDonald, 1976).

Psychologists and cognitive scientists typically differentiate between controlled and automatic cognitive processes. Controlled processes are defined as effortful, slow, and attention demanding whereas automatic processes are generally effortless, fast, and require little or no attention (Shiffrin & Schneider, 1977). Once a process is automatized (usually through extensive exposure or practice), it becomes difficult to regain control over it. Hypnotic researchers have taken advantage of this phenomenon, exploring the three tasks described above (in all of which the dominance of an automatic process impedes performance) to illustrate that hypnotic suggestion can shift certain automatic processes back into the purview of control. Specifically, in each of these three tasks, hypnotic suggestion helps individuals ignore the semantic meaning of words, ignore distractor arrows, or afford more importance to auditory, rather than visual, pathways, respectively. In fact, past research demonstrates the possibility to reduce (Raz et al., 2005; Raz, Kirsch, et al., 2006; Raz et al., 2002) or even remove the Stroop interference effect (Raz & Campbell, 2011; Raz et al., 2003), increase performance on the flanker task (Iani et al., 2006), and substantially hinder the McGurk effect (Lifshitz, Aubert-Bonn, et al., 2012). While these tasks have become gold standards in the objective assessment of hypnotic, post-hypnotic, and non-hypnotic suggestions, they only allow us to determine how the *withdrawal* of specific information modulates performance.

Automatization

In the present study, we sought to use the potential of the ODP — in which *adding* specific information (i.e., making the occluders visible) affords better performance on the task — in order to develop a new perceptual task that could be used in future hypnotic studies assessing visual hallucination. Our present purpose is thus to develop, assess, and document our new task (MoTraK), rendering it a valid and reliable perceptual assessment. We will first describe the variations of the task with the ODP illusion and then explain the results we collected for each variation in greater detail. Our general hypotheses followed the trend proposed by Lorenceau and Shiffrar (1992), and McDermott et al. (2001): perceiving the motion with invisible occluders should result in poor performance (i.e., near-chance accuracies and long reaction times), while performing the task with visible occluders should induce very high performance (i.e., near-perfect accuracies and fast response times). In addition, we postulated that there would be no practice or learning effects on MoTraK. Specifically, we hypothesized that repeating the task with invisible occluders would not influence performance, and that performing the task with visible occluders would not bolster subsequent performance of the task with invisible occluders.

Methods

Participants

Participants included 263 undergraduate university students who volunteered to participate in exchange for course credit. All participants were enrolled at McGill University, over 18 years of age, and had normal or corrected-to-normal vision. We excluded participants who had unrealistically fast response times (< 30 ms per trial) or incomplete recording of data. We divided participants into several groups, described in the *Procedures* section.

Materials

We constructed a web-based Adobe® Flash® task that we distributed to participants via a Uniform Resource Locator (URL) in email invitations. We designed the task, MoTraK, using variations of the ODP. Some trials reproduced the original revolving diamond; others introduced a variation of the ODP, in which a triangle replaced the original square (diamond). The assessment included 72 outlines of geometric shapes in motion — 36 squares followed by 36 triangles — with their apexes occluded by shapes that matched the colour of the background. As a result, only segments of the geometric outlines (i.e., four straight segments on square trials and three straight segments on triangle trials) were visible, while all corners where completely invisible and replaced by aperture effects (see Figure 4). We used homogenous web colours: uniform grey for the geometric shapes (#666666; RGB: R=102, G=102, B=102; CMYK: C=60, M=51, Y=51, K=20) and black for the background and occluders (#000000; RGB: R=0, G=0, B=0; CMYK: C=75, M=68, Y=67, K=90), resulting in medium contrast which creates a low coherence of motion (Lorenceau & Shiffrar, 1999). We rotated the squares and triangle by 45 and 60 degrees, respectively, between each trial to discourage participants from replacing the occluders with physical aids (e.g., stickers on the screen). We created a second version of the task, in which the occluders were white (#ffffff; RGB: R=255, G=255, B=255; CMYK: C=0, M=0, Y=0, K=0) and fully visible (see the Procedure section).

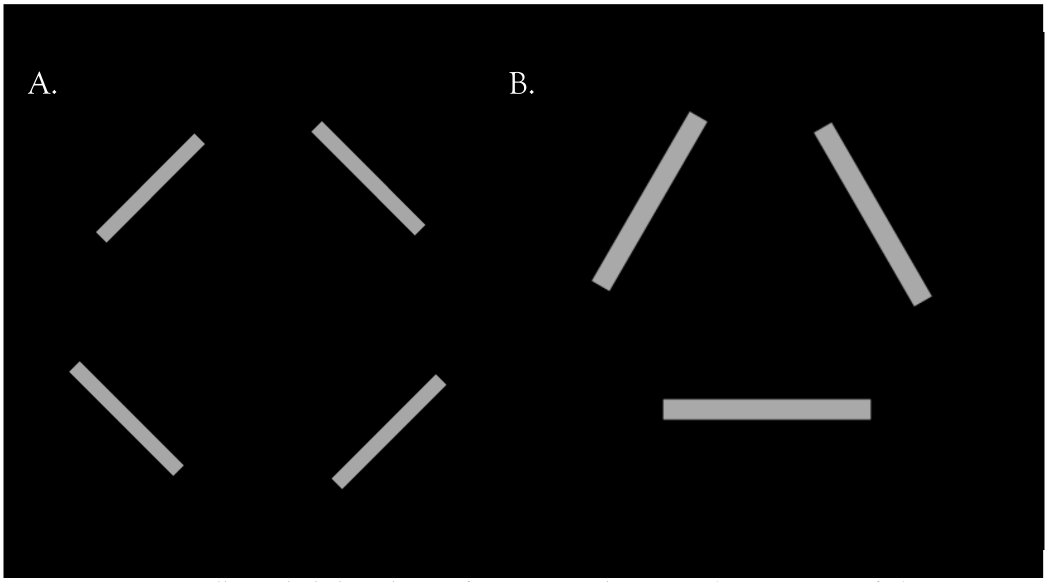

Figure 4. *Partially occluded outlines of geometric shapes.* Only segments of the geometric outlines were visible; all corners where completely invisible and replaced by an aperture effect. As a result, four straight segments were visible on square trials (A) and three straight segments were visible on triangle trials (B).

The geometrical shapes moved in a circular trajectory, either clockwise or counter-clockwise for the square trials (18 trials in each direction, pseudo-randomly displayed), and clockwise, counter-clockwise, or in directionless motion for the triangle trials (12 trials in each condition, also pseudo-randomly displayed). We took advantage of the uneven number of segments in the triangle to create directionless motion, in which the triangle appears to increase and decrease in size without following a particular trajectory. Because determining the direction of motion on MoTraK is very difficult, participants tend to believe that most trials represent directionless motion. To avoid having participants focus on directionless motion in the square trials, MoTraK always presented the triangle trials (and thus the directionless motion option) after presenting the square trials.

To ensure that participants understood the task, we included two short training periods in the pre-assessment of MoTraK. The first training session occurred before the square trials, during which participants went through two 15-

second interactive demonstrations (in which participants could make the occluders visible or invisible on a moving — first clockwise, then counter-clockwise — pentagon). Next, the participants practised on a few trials with feedback stating whether their responses were "correct" or "incorrect". The practice trials consisted of six pentagon trials, three clockwise and three counter-clockwise trials, all pseudo-randomized. After the practice trials, participants received a short notice informing them that they would not receive feedback in future trials. The second training session occurred between the square and the triangle trials, during which participants viewed a single interactive demonstration of directionless motion on a pentagon. The post-assessment of MoTraK included no demonstration, only three practice trials with feedback.

Our Adobe® Flash® interface automatically recorded response time and accuracy, and immediately sent the measures to a php–MyAdmin password protected MySQL™ online database. Responses were recorded when participants depressed keys on a standard QWERTY keyboard: the “F” key for counter-clockwise motion, the “J” key for clockwise motion, or the spacebar for directionless motion (on triangle trials only). The response time measurements on the Adobe® Flash® program were accurate within 4–10 ms of the response time measured with a photoelectric cell. Each trial was displayed for an infinite period of time until participants responded.

Procedures

We separated our participants into several subgroups that we outline in Table 1.

Group	Condition							
	Pre-assessment				Post-assessment			
	Invisible Occluder		Visible Occluder		Invisible Occluder		Visible Occluder	
	Online	In the lab	Online	In the lab	Online	In the lab	Online	In the lab
1 (Baseline) N = 94	X							
2 (Repeat) N = 49	X					X		
3a (I-V) N = 43	X						X	
3b (I-V: lab) N = 14		X						X
4a (V-I) N = 46			X		X			
4b (V-I: lab) N = 17				X		X		

Table 1. *Groups.* The "X" indicate the occlusion (visible or invisible occluders) and setting (online or in the laboratory) of each group in each condition (pre- and post-assessments).

i) Pre-assessment

As shown in Table 1, some participants performed the pre-assessment with invisible occluders (groups 1, 2, 3a and 3b), while others performed it with visible occluders (groups 4a and 4b). We provided all volunteers with a URL to MoTraK and asked them to complete the task either online (groups 1, 2, 3a, and 4a) or supervised in the laboratory (groups 3b and 4b). The entire task lasted approximately fifteen minutes. A written notice in the task asked participants to remain in a calm environment free of distractions. Participants provided consent by clicking on the “Accept” button following the consent information (see Appendix A), which informed them of their right to withdraw from the study at any point in time and that the information and data gathered (including response time and accuracy) could be used for scientific purposes. Demographic information gathered included gender, education, and handedness. We also collected student identification numbers and IP addresses to allow for the exclusion of participants who completed the task more than once. After completing the task online, all but group 1 participants received an automatically generated email inviting them to participate for a second time online (groups 3a and 4a) or in the laboratory (groups 2, 3b, and 4b).

When completing the pre-assessment in the laboratory, a female experimenter greeted participants and asked them to follow her into a quiet room where a computer was set up with the experiment. The experimenter sat beside the participant and monitored her or his movements, making sure she or he would remain seated in a stable and appropriate position: head positioned straight and eyes opened normally at an approximate distance of 45 cm from the screen. The task was the same as the one used online.

ii) Post-assessment

As previously mentioned, certain participants performed the post-assessment with invisible (groups 2, 4a and 4b) or visible (groups 3a and 3b) occluders. When performing the post-assessment online (groups 3a and 4a), participants had a mandatory 5-minute break after which they received an email containing a link to the post-assessment. The email informed participants that they must complete the post-assessment within one hour for their participation to be valid. When performing the post assessment in the laboratory, participants who had also performed the pre-assessment in the laboratory (groups 3b and 4b) had a 5-minute mandatory break after which an experimenter escorted them to the post-assessment. Participants who performed the pre-assessment online but came to the lab for the post-assessment (group 2) waited approximately one week between the two assessments. As in the pre-assessment, experimenters monitored the head positions, eye opening and general posture of participants completing the post-assessment in the laboratory. After participants completed the post-assessment in the laboratory, the experimenter escorted them out of the room, verbally debriefed them, and gave them a paper copy of the debriefing (Appendix B).

iii) Perceived accuracy

After completing each MoTraK assessment, participants from groups 2, 3a, 3b, 4a and 4b rated their perceived accuracy on the square and on the triangle trials. To do so, MoTraK redirected participants to a page displaying two likert scales ranging from "Very accurate" to "Very inaccurate", with a middle point stating "At chance level": one for squares, and one for triangles (see Appendix A).

iv) Informal interviews

Approximately one week after participants from groups 3a, 3b, 4a and 4b completed both parts of the task, we contacted 10 participants who performed either very poorly or very accurately (below 10% or above 90%) on one or both shapes of MoTraK with invisible occluders, or who performed poorly on one or both shapes of MoTraK with visible occluders (below 85%) and invited them to participate in a 5–minute informal telephone interview to determine whether they used a particular strategy when completing MoTraK (an interview guide is available in Appendix C).

Results

We performed our analyses using the statistical software SAS version 9.2. We used repeated measures analyses of variance (ANOVA) using the MIXED procedure.

Demographics and baseline performance

Our participants included 259 females and 98 males with a mean age of 20.7 years old (SD = 2.35 years old; minimum 18 and maximum 45 years old). Out of the participants, 86.5% were right-handed, 10.5% were left-handed, and 3% declared being ambidextrous.

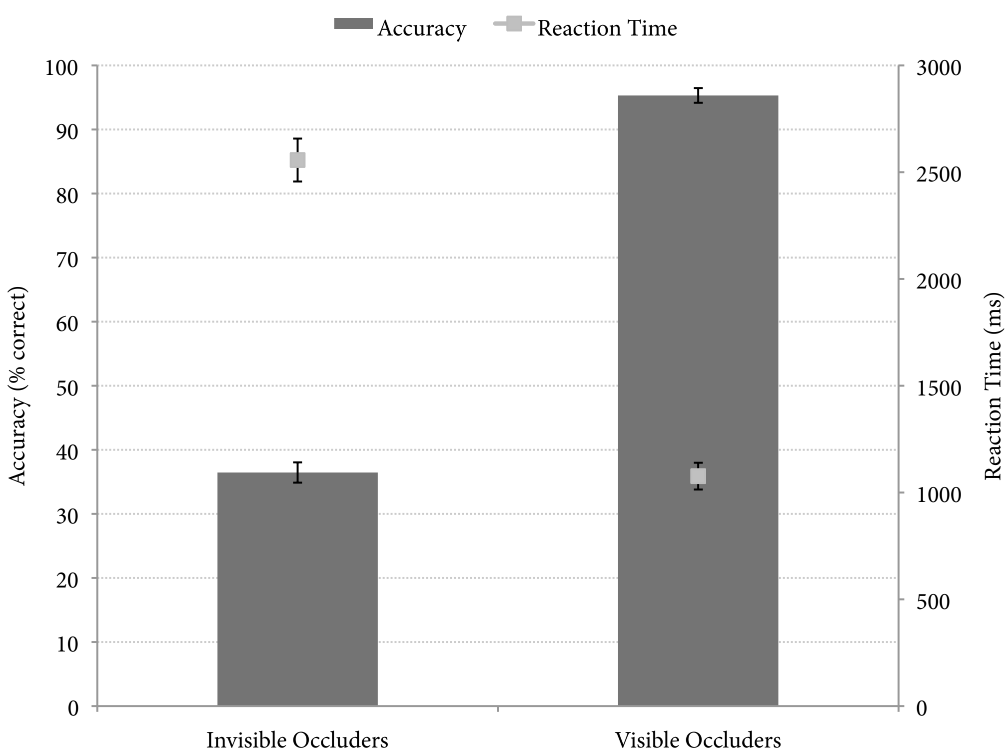

Figure 5. *Average baseline performance.* Average performance on MoTraK with invisible (N = 237) and visible (N = 63) occluders.
Error bars represent standard error.

A table displaying the average accuracy and reaction times for each group in each condition is available in Appendix D. When performing the task for the first time in the pre-assessment with *invisible* occluders, participants (N = 200) obtained an average accuracy of 36% (SD = 24%) and took on average 2557 ms to respond (SD = 1547 ms). With *visible* occluders, participants (N = 63) were 95% accurate (SD = 8%) and performed the task within an average time of 1077 ms (SD = 497 ms; Figure 5).

Analysis of our data revealed that in the pre-assessment, the groups who performed the task with invisible occluders (i.e., groups 1, 2, 3a and 3b) had similar average accuracies and reaction times with one another.

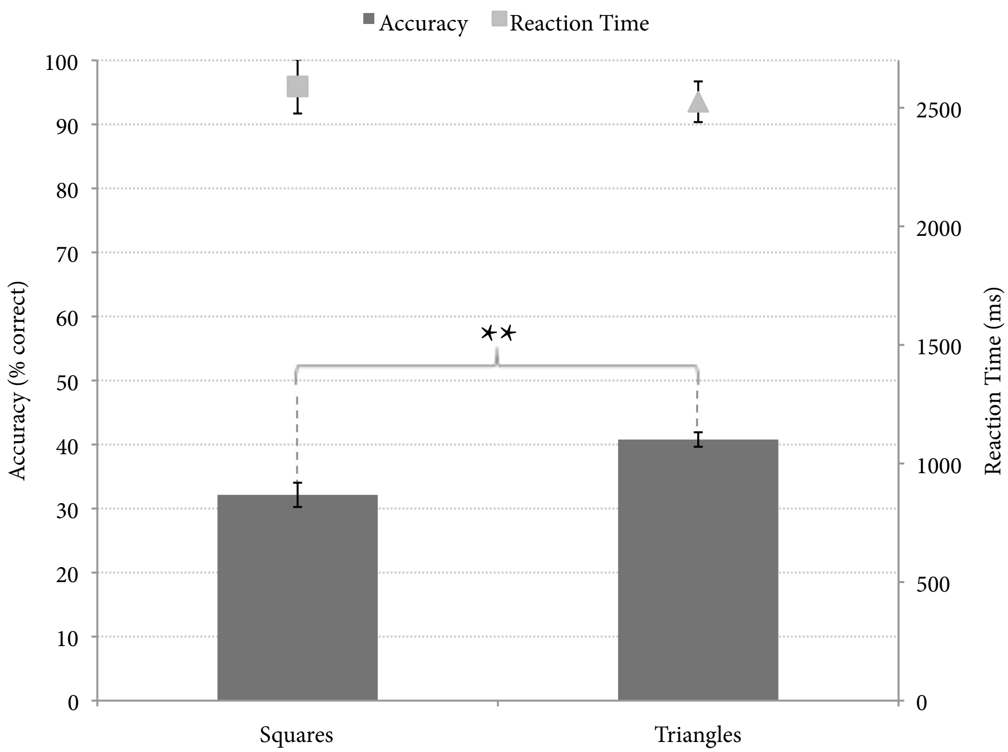

Figure 6. *Shape differences.* Average accuracy and reaction time on each shape in the pre-assessment of MoTraK.
** = p < 0.01; error bars represent standard error.

Accuracy, but not reaction time, differed according to the shape of the trials (Figure 6). Specifically, combined performance of groups 1, 2, 3a and 3b in the pre-assessment revealed that participants were more accurate [F(1, 199) = 12.92, p < 0.001] on the triangles (average accuracy = 41% correct, SD = 17%), compared to the squares (average accuracy = 32% correct, SD = 29%). However, because our scope is oriented on the task in general rather than on the individual shapes, we performed the subsequent analyses on overall average performances, looking at the shape together rather than separately.

Familiarity effects

i) Familiarity on the task with invisible occluders

To discern the effects of practice on MoTraK, we compared performance on the pre-assessment to performance on the post-assessment in group 2.

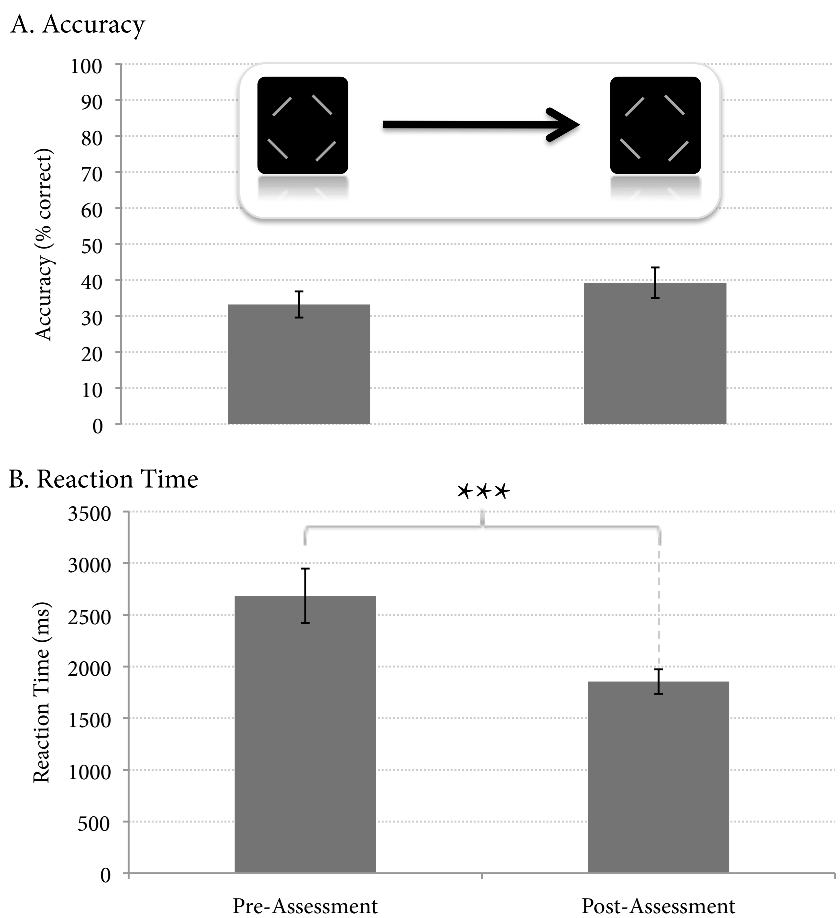

Figure 7. *Familiarity effects.* When completing MoTraK for the second time (post-assessment), participants obtained similar accuracies (A), but performed faster (B).

We found that prior performance of MoTraK accounts for faster reaction times (RT) in the post-assessment (post-assessment average RT = 1855 ms, SD = 826 ms; pre-assessment average RT = 2685 ms, SD = 1846 ms; $F(1, 199) = 15.81$, $p < 0.001$) but no significant difference in accuracy (Figure 7).

ii) Performing with visible occluders prior to performing MoTraK

We looked at whether performing the task with visible occluders influences performance on subsequent completion of the task with invisible occluders. To investigate this phenomenon, we compared the performance of groups 3a and 3b in the pre-assessment to that of groups 4a and 4b in the post-assessment.

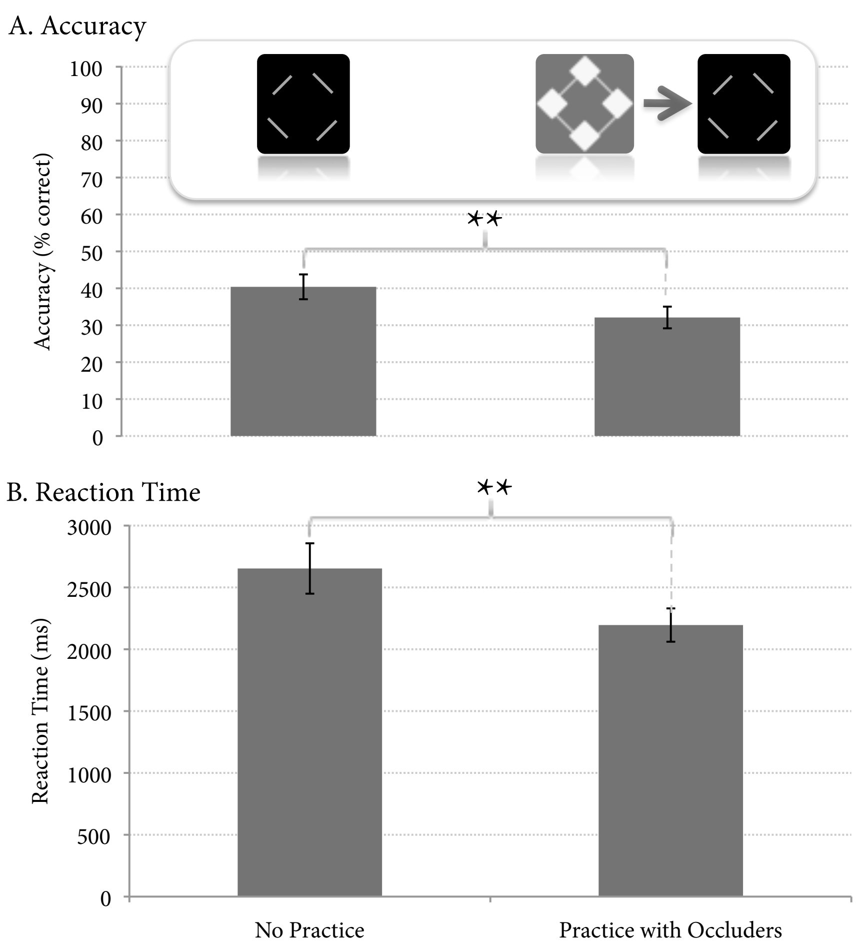

Figure 8. *Familiarity with visible occluders.* Participants who completed a variation of MoTraK with visible occluders performed less accurately (A), but faster (B) than participants who completed MoTraK for the first time.
** = $p < 0.01$; error bars represent standard error.

On the one hand, we found that participants who had no prior familiarity with the occluded version of the task (groups 3a and 3b) were surprisingly more accurate (M = 40% accurate, SD = 25%) than participants who performed the task with visible occluders (group 4a and 4b) prior to performing the post-assessment with invisible occluders (M = 32% accurate, SD = 23%; $F(1,118) = 6.97$, $p < 0.01$). On the other hand, participants with prior experience on MoTraK with visible occluders (groups 4a and 4b) performed faster (M = 2196 ms, SD = 1069 ms) than participants with no prior experience (group 3a and 3b; M = 2653 ms, SD = 1537 ms; $F(1, 118) = 6.94$, $p < 0.01$; Figure 8).

Setting effects

To investigate whether the setting in which participants completed the task (online or under supervision in the laboratory) influenced their performance on MoTraK with invisible occluders, we compared the pre-assessment performance of participants in group 3a to that of participants in group 3b. We found no influence of setting on performance: accuracies and RT were similar for both groups.

Gender differences

Looking at gender differences on the pre-assessment performance of MoTraK with invisible occluders, we found that female participants performed faster than male participants [$F(1, 199) = 9.15$, $p < 0.01$]. While males and females did not significantly differ in terms of accuracy, males were marginally more accurate [$F(1, 198) = 3.28$, $p = 0.0718$] than females (Figure 9).

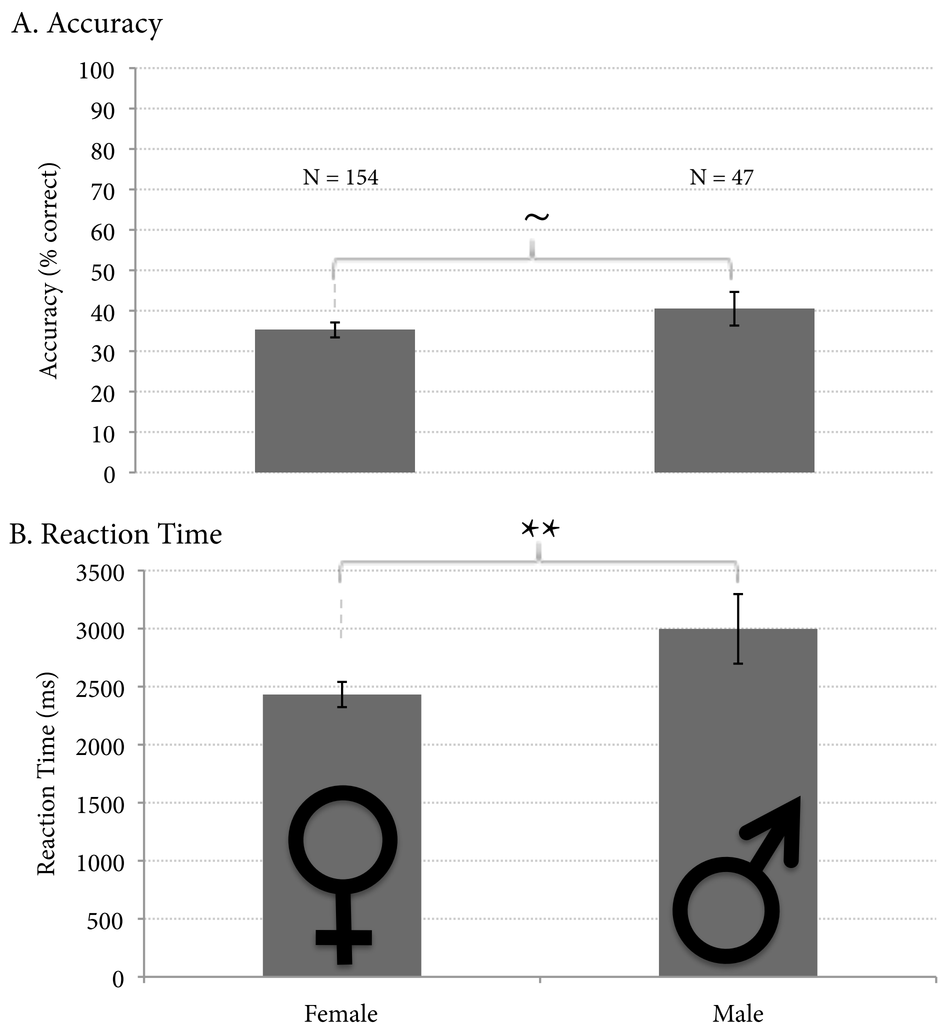

Figure 9. *Sex differences.* Females performed significantly faster (B) but marginally less accurately (A) than males on MoTraK.
~ = marginal significance; ** = $p < 0.01$; error bars represent standard error.

Differences between handedness

We compared the performance of individuals according to their handedness. While we assessed very few ambidextrous individuals (N=6), we considered the findings interesting and decided to report them whilst insisting on the fact that they are of little validity and should be regarded as a curious phenomenon that calls for further analyses. After performing a one-way ANOVA of handedness (left-handed, right-handed, or ambidextrous), we found a main effect of handedness on accuracy on the pre-assessment with invisible occluders [$F(2, 197) = 3.13$, $p < 0.05$]. In terms of accuracy, post hoc least significant difference (LSD) t-tests revealed that, while left-handed and right-handed participants performed similarly, ambidextrous participants (M = 51% correct, SD = 33%) outperformed both right-handed (M = 36% correct, SD = 24%; $t(197) = 2.05$, $p < 0.05$), and left-handed participants (M = 31% correct, SD = 20%; $t(197) = 2.49$, $p < 0.05$). Handedness had no effect on RT (Figure 10).

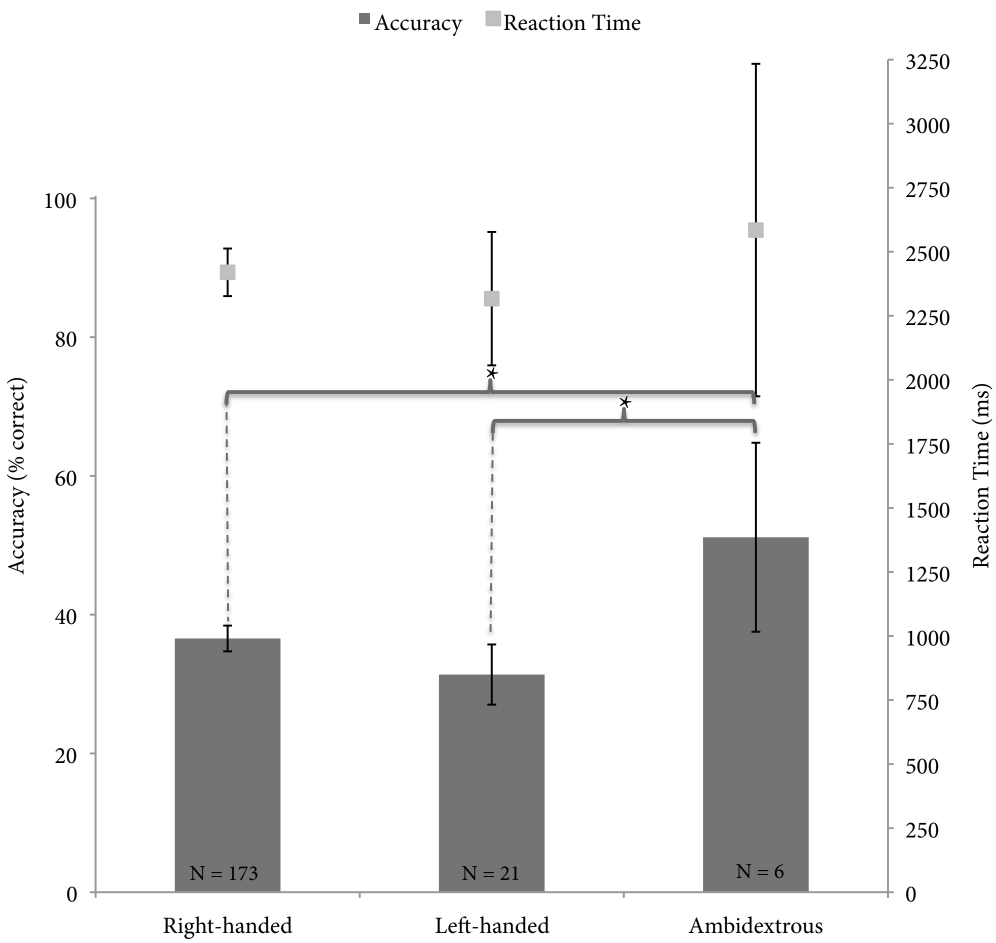

Figure 10. *Handedness effects.* While handedness did not seem to affect reaction time on MoTraK, ambidextrous participants were significantly more accurate than both left- and right-handed participants.
* = p < 0.05; error bars represent standard error.

Correlation between perceived accuracy and observed accuracy

i) In the pre-assessment with invisible occluders

Correlating the accuracy participants obtained on each shape in the pre-assessment with invisible occluders to the subjective ratings of accuracy yielded a significant ($p < 0.05$), albeit weak, Pearson correlation coefficient of 0.169. This result indicates that even though participant reports generally reflected objective measures of accuracy, this subjective rating was somewhat imprecise.

ii) Females versus males in the pre-assessment with invisible occluders

Looking at the correlation between perceived accuracy and recorded accuracy for males and females separately, we found that females ($N = 154$) were not accurate in estimating their own accuracy (Pearson correlation coefficient = 0.075, $p = 0.3442$) while males ($N = 47$) showed a significant correlation between their estimated accuracy and their actual accuracy (Pearson correlation coefficient = 0.3514, $p = 0.0142$).

iii) With visible occluders

When occluders were visible, participants were apt in their estimation of their own accuracy ($p < 0.0001$), with a moderate Pearson correlation coefficient of 0.3391 between actual and perceived accuracy.

Informal interviews

Semi-structured informal telephone interviews (an interview guide is available in Appendix C) with participants from groups 3a, 3b, 4a, and 4b who obtained extreme (very accurate or very inaccurate) scores yielded a wide diversity of responses. In the joint display depicted in Table 2, we provide a transcription of the strategies employed and described by each interviewed participant. We included corresponding accuracies in the joint display to allow a better comparison of strategies. Amongst the range of described strategies, participants stated trying to see the holistic motion of the shape; using their "gut feelings" or first impressions; focusing on a single segment rather than the whole; tracking the motion with their fingers; or using no strategy at all and simply guessing randomly. Some participants obtaining very similar accuracies reported opposing strategies. For example, while they both performed very well on MoTraK, participant S10 mentioned that "if you could see [the segments] kind of progressing counter-clockwise, then the item would be spinning counter-clockwise", while participant S4 mentioned that "when the object itself was rotating one way, the individual pieces would seem to go in the opposite direction." The disparity and variety of these reported strategies propose that a unifying strategy is unlikely to fully explain high (or low) performance on MoTraK. These sparse results do not allow us to infer that MoTraK is immune to heuristics, in fact, some reviewers of this thesis mentioned that, after observing practice trials repeatedly, they were able to determine a pattern that allowed them to perform very accurately on MoTraK. While the little number of interviews conducted in this study does not allow us to preclude the possibility that participants also found such strategy, they seem to indicate that, considering the little number of practice trials included in MoTraK, participants had little chance of identifying such one-size-fits-all strategic pattern. We will discuss this conclusion in greater depth in the discussion.

Subject	Condition	Accuracy	Quotations
S1	IC	Sq:	*«Without the occluders I was trying to see all the pieces moving at once instead of one by one, I guess the holistic sort of the motion and see if that looks familiar going to the right or going to the left from what I've see before.» «Without the occluders, for some of the stuff I fell confident, other stuff I had no idea whether I was right or wrong.» «[with the occluders] I fell much more confident. I fell like I was doing O.K. for most of that if not all of it.» «I think triangles were a bit harder, because they had less clues, moving parts. [...] without the occluders though I fell like the random motion was easier to recognize».*
		Tri:	
	VC	Sq:	
		Tri:	
S2	IC	Sq: 1	*«When the bars were moving with no light shapes [occluder] it was really hard to distinguish clockwise and counter-clockwise. Most of the time I had no idea. [...] I took a gut feeling and I guessed at it but I couldn't really tell.» «The second part [with visible occluders] was much easier to distinguish.» «I found the pentagon easier than the squares.» «We had the little demo where we could see it with the occluders and without and I remember trying to think of something to look out for, look for a pattern, like what the motion looked like without the occluders. But then as soon as it went into the real assessment with no occluders I couldn't remember, I couldn't distinguish, and I had a really hard time trying to figure out if it was supposed to be clockwise or counter-clockwise.» «I was trying to look at the bars and to visualize the occluders there to figure it out, but I found it strenuous.»*
		Tri: 8	
	VC	Sq: 35	
		Tri: 32	
S3	IC	Sq: 8	*«I think the part where we only had the option of left or right [squares] was the only part I found pretty easy. The rest I found pretty hard.» «I found the squares easier because of the flat pieces: flat across the top, flat across the bottom, so it's easier to watch which direction it's going, rather than the triangles which were on the angles so it was a bit harder.» «[For the triangles] I would just watch one piece and try and decide which direction it was going in. [...] but because of the angles on the pieces of the triangles, I found it really hard to determine which direction it was going in.»*
		Tri: 15	
	VC	Sq: 36	
		Tri: 25	
S4	IC	Sq: 35	*«At first, it was a little bit difficult to discern the pattern without the blockers up. Then I started to realize there was a pattern to how the blocks moved and once I understood how they related in some ways [...] I couldn't explain how I was able to see it but I feel like when the object itself was rotating one way, the individual pieces would seem to go in the opposite direction.» «If you consider the centre of the shape to be the focal point, I was watching as each of the lines fell towards the focal point and then I watched in the order in which they were getting there. Then it seemed to me that as each one fell so to go in a clockwise direction that they were falling, the shape itself would appear with the blockers up to move in counter-clockwise motion.» «I feel like the triangle was little bit more difficult because there were no practice trials for that one»*
		Tri: 35	
	VC	Sq: 36	
		Tri: 35	

Table 2 (1 of 3). *Joint display of select participants accuracies and explained strategies.* The quotations were obtained via semi-structured informal telephone interviews. (S= subject; IC = invisible occluders; VC = visible occluders; Sq = square; Tri = triangle)

S5	IC	Sq: 1	*«[With visible occluders] it was easier but it was still hard. [...] The only time I was not actually just guessing was when the occluders were on and there wasn't the directionless movement.» «I didn't have a conscious strategy. It was hard for me to even tell at all what was happening.»*
		Tri: 13	
	VC	Sq: 36	
		Tri: 18	
S6	IC	Sq: 0	*«If it was going to the right, I would look for maybe two of them going in the same direction that looked like they were going to the right or clockwise.» «Then a part would come up when there is no direction at all and you would just press the space bar, the way I would determine that the shape had no direction is if none of the [segments] were going in a synchronous motion. They were all on their own tracks.» «with more sides, it was a little more difficult to determine the motion [...] I think the triangle was the easiest because it had the least number of sides.» «In the introduction part I was really confused, thinking «what am I doing?» but then I got more and more used to it and tried to determine whether something was clockwise or counter-clockwise I started to look for one specific thing [the specific direction of one or two segments] and once I saw that I would pick one.»*
		Tri: 7	
	VC	Sq: 35	
		Tri: 35	
S7	IC	Sq: 3	*«C'était plus difficile une fois qu'on retire les repères et qu'il y a seulement les barres et il faut essayer de savoir dans quel sens ça bouge.» «Les triangles étaient un peu plus facile que les carrés.» «Au début j'y allais plutôt au hasard et puis petit à petit j'ai essayé de comprendre comment ça marchait et en fait j'ai essayé de replacer en quelque sorte les repères sur l'image du point de vue visuel, mais je ne suis pas sur que ça ait marché.»*
		Tri: 10	
	VC	Sq: 30	
		Tri: 35	
S8	IC	Sq: 0	*«I don't think one [shape] was necessarily harder than the other.» «I really went with the first thing that went through my mind. I did try to see if a certain... whenever it rotated, whatever direction, I think that the parallel lines, especially with the squares or shapes like that that had parallel lines, they would move in certain patterns, sort of a rotation, but I couldn't figure it out, I just went with whatever I thought.»*
		Tri: 6	
	VC	Sq: 35	
		Tri: 36	

Table 2 (2 of 3). *Joint display of select participants accuracies and explained strategies.* The quotations were obtained via semi-structured informal telephone interviews. (S= subject; IC = invisible occluders; VC = visible occluders; Sq = square; Tri = triangle)

S9	IC	Sq: 17	*«I fell distracted because of the light that was flashing [...] probably [affected the way I performed], I don't think I performed very well.» «I think it was easier with the blocks covering [...], without it was more difficult.» «I would put my fingers close to the screen and move them in what direction it was going. [...] I would have one finger to press the key and then the other one I'd put up to the screen and kind of try to trace the motion. I wasn't using my fingers when there were no white blocks.» «I did better without occluders [...] because I feel like the motion was more blocked [with the occluders].*
		Tri: 9	
	VC	Sq: 28	
		Tri: 30	
S10	IC	Sq: 33	*«The task was challenging [...] The parts without the occluders were the most challenging ones. [...] it was quite challenging to identify a pattern that would result in clockwise or counter-clockwise motion.» «The pattern I identified was that one had to watch for the various bars to be coming in and going out in a certain order and if you could see them kind of progressing counter-clockwise, then the item would be spinning counter-clockwise, and if you see them progressing clockwise, in terms of their in and out oscillations then the item would be progressing clockwise. That being said knowing that in theory didn't make it easy to do in practice, it was rather difficult to identify.» «With the occluders it was fairly simple, somewhat harder when I had to identify non-clockwise or -counter-clockwise motions in the third section with triangles.» «It [the task] got more challenging as the number of sides dropped, so that triangles were more challenging than squares which were more challenging than pentagons. [...] Because I was trying to identify a pattern in the oscillation, when there are more lines then I'm able to follow that pattern around more easily than where there are fewer lines. [...] I'm trying to assess whether, in the triangles, after one [segment] goes in, it's the one to the right that goes in or the one to the left, whereas with the pentagon [...] I'm able to track a pattern around the shape.» «If it were moving clockwise, the top bar would move in to the closest point to the centre, and then the next to move in to the closest point would be the one to the right, and then the bottom one would move closest, and then the last one would move closest. And the top, and the right, and the bottom and the left, and proceed in that pattern. Then it would be reversed if it were spinning counter-clockwise. And if there isn't that pattern, than the object would not be spinning clockwise or counter-clockwise.»*
		Tri: 31	
	VC	Sq: 36	
		Tri: 31	

Table 2 (3 of 3). *Joint display of select participants accuracies and explained strategies.* The quotations were obtained via semi-structured informal telephone interviews. (S= subject; IC = invisible occluders; VC = visible occluders; Sq = square; Tri = triangle)

Limitations

Several methodological changes could be made to strengthen MoTraK in future studies. First, as pointed out by the reviewer of the present thesis, we may want to create a new version of MoTraK using a fixation cross between the trials to encourage participants to look straight at the screen and avoid that they use strategies such as completing MoTraK using their peripheral vision. It would also be extremely useful to use a head to ensure that participants do have a standard head position, and to track their gaze using eye-tracking systems. Nonetheless, while the latter two implementations would substantially improve the quality of investigations of MoTraK, they would inhibit online assessment, which is one of the strengths of MoTraK as it stands currently.

Discussion

If used with care, MoTraK may be a suitable task for neuropsychological and cognitive assessments. Few participants performed exceptionally well with invisible occluders or, conversely, very poorly with visible occluders (see examples of individual scores paired with strategy description in the interviews joint display Table 2). We nevertheless found that on average, completing MoTraK with invisible occluders resulted in poor performance (i.e., low accuracy and slow RT), while completing the task with visible occluders resulted in strong performance (i.e., near perfect accuracy and fast RT). These results support earlier findings of Lorenceau and Shiffrar (1992) and of McDermott and colleagues (2001).

Our findings propose that, with invisible occluders, participants are less accurate, but faster on the original diamond (square) trials designed by Lorenceau and Shiffrar (1992) than on the triangle trials our team designed. This finding goes against our hypothesis stating that accuracy should approximate chance level: 50% on the square trials given that there are two possible directions (clockwise and counter-clockwise), and 33% in the triangle trials in which three directions are possible (clockwise, counter-clockwise, and directionless motion). A possible explanation for this discrepancy is that the so-called "directionless motion" may have been easier to decipher than the other directions. Further investigations should look into the accuracy difference when MoTraK is performed with, and without directionless motion trials. Additionally, it is interesting to note that average performance on the square trials with invisible occluders is curiously below expected chance levels. This finding seems to indicate that participants are not simply 'guessing' the answer, but that they possibly answer using a particular pattern of response. This finding further limits our ability to conclude that participants did not use a unifying strategy, a problematic that we will discuss further below.

Our findings show that RT on MoTraK with invisible occluders is sensitive to familiarity with the task, but that accuracy is not. In other words, having experienced MoTraK with invisible occluders makes participants faster, but not more accurate, on a second completion of the task. We also found that having performed a variation of MoTraK in which occluders are visible prior to completing the task with invisible occluders enhances participants speed yet decreases their accuracy. Taken together, these two findings propose that familiarity with the task seem to stimulate rapidity, yet, probably due to the absence of feedback, that it does not promote accuracy.

Investigating the influence of several potential confounding variables on performance, we found that i) the task was not subject to setting effects — performance in the lab parallels performance online; ii) performance differed according to sex — male participants were slower than female participants, but tended to be more accurate even though the difference was not significant; and iii) performance may hinge on handedness, yet further investigations are needed to confirm this trend. Future research looking at the differences in brain activity (using functional magnetic resonance imaging [fMRI] or event-related potential, for example) that occur when people of different gender or handedness complete MoTraK may help shed light on the perceptual aspects governing this visual illusion and help us understand such perceptual phenomenon better.

When looking at participants' perceived accuracy on MoTraK with invisible occluders, we found that participants appear to be able to estimate, at least in part, their accuracy. When looking at gender separately, however, we found that only males show a positive correlation between their perceived and observed accuracies; females did not show such correlation, proposing that perception on a difficult task without feedback may be different for males and females. With visible occluders, participants are much more precise and accurate in estimating their accuracy.

Finally, as we may understand from the interviews, while most people admitted having developed a strategy for performing the task, the strategies varied widely; sometimes, the strategies used opposed each other despite yielding similar performances. From our results alone, it seems that no overarching strategy is able to govern performance on MoTraK. Nonetheless, the examiner of the present thesis and some members of his lab noted that repeated practice trials allowed them to identify a pattern that would help them perform better on MoTraK. This strategy (reverse pattern) seems to be the strategy identified by the interviewed participant S10. While we may not preclude the possibility that more participants discovered and used this strategy, low average accuracies seem to indicate that the majority of participants were unable to identify such strategy. Unfortunately, the work of the current thesis was performed using a version of MoTraK that comprised very few practice trials. We acknowledge that a more extensive investigation of potential learning effects and strategies is primordial to allow stronger conclusions on future uses of the task in cognitive experiments.

Taken together, our findings provide insight into the average performance and variables that may alter performance on MoTraK. In light of our findings that i) accuracy on MoTraK does not improve with familiarity with the task; ii) performing the task with visible occluders results in near-perfect accuracies; and iii) at least most participants appear to perform without using a uniform strategy, we consider MoTraK to be well-suited for cognitive neuroscience assays, such as assays using hypnosis to induce visual hallucination.

MoTraK and hypnotic suggestions

Hypnotic suggestion to visually hallucinate white occluders, if effective, should substantially improve performance on MoTraK and increase the accuracy and the response speed of participants. Using MoTraK in hypnotic research, therefore, would open a new branch of investigations in which we hope to be able to determine whether a hypnotic suggestion meant to add critical information in the form of a hypnotic hallucination may transform a difficult, effortful task into an easy, effortless one. Despite the narrow implications of a task like MoTraK, having new tools to investigate and understand the automatization of cognitive processes, as well as the control by cognitive processes of perceptual inputs, opens the door to a broad range of research, ranging from learning and education to mind–body interactions.

Connecting Ideas: Manuscript Two

The second manuscript of the present thesis is the core of our investigation, and answers the overarching research question: *Can hypnotic suggestion add critical visual information to make a difficult task substantially easier?* In this manuscript, therefore, I will detail the design we used to answer our research question and I will describe our full results in detail. Using MoTraK to probe the interaction between controlled and automatic processes, this third manuscript goes hand-in-hand with Manuscript One, which extensively explored and described MoTraK. It is inspired by past studies that showed how a suggestion may de-automatize deeply entrenched processes and explores how hypnotic suggestion may move automaticity in the opposite direction and render a controlled process largely automatic.

Manuscript Two

Hypnotic suggestion enlightens missing information: an empirical study of hallucination

Noémie Aubert Bonn*, Alexandra Fischer†, & Amir Raz*

Departments of Psychiatry* and Psychology†, McGill University, Montreal, QC, H3W 1E4, Canada

Abstract

A common trend of research found that a hypnotic suggestion to *remove* critical information can derail automatic processes that otherwise reside largely outside of conscious control. Here we explored whether a hypnotic suggestion to *add* critical visual information would render an otherwise difficult visual task easier. We used MoTraK, a task in which the addition of simple visual elements suffices to transform a difficult visual processing task into an easy, effortless one, to test whether suggesting those missing elements would increase performance of amenable individuals. Sixteen highly suggestible individuals (HSIs; i.e., likely to respond to hypnotic suggestion) and 16 less suggestible individuals (i.e., very unlikely to respond to hypnotic suggestion) completed MoTraK a first time under normal waking state, and a second time with the hypnotic suggestion to add the simple visual elements. While both groups responded faster under suggestion, only HSIs performed more accurately after receiving the suggestion. Our findings intimate that the suggestion may have enabled HSIs to envisage the visual information, and pave the road to a more complete understanding of mind–body interactions and other top–down modulations.

Keywords: *MoTraK; hypnotic suggestion; automatization; top–down modulation; hallucination; positive hypnotic hallucination*

Introduction

The presence or absence of specific information can exert a crucial influence on the cognitive and perceptual processing of various tasks. In some cases, physically distorting a perceptual scene (e.g., sound, image, etc.) may preclude an individual from obtaining information essential to the completion of a task or mental process. Visual illusions accurately portray how removing or adding minimal information may suffice to turn a simple perceptual scene into an ostensibly incomprehensible one.

Recent research proposes that, in the absence of physical changes of a perceptual scene, cognitive modulations such as specifically tailored hypnotic and non-hypnotic suggestions may suffice to distort perceptual processing by withdrawing or adding essential information. As a result, suggested perceptual changes alone may create or resolve perceptual illusions. Such top-down influence typifies the regulation by higher cognitive systems of bottom-up sensory physiological mechanisms.

Suggested hallucinations

Current conceptions concerning the vividness of hypnotic hallucinations bring about the expression of a broad range of opinions as researchers tend to disagree on the extent to which suggestion modulates perception. First, we will review studies supporting that hypnotically induced hallucinations may be vivid enough to disrupt perceptual processing and influence behaviour. Second, we will explore opposing evidence supporting that hallucinations exert very little influence on perception and that changes in behaviour are mostly attributable to theatrics. We will then explore a middle ground between these views in light of which hypnotic hallucinations may be the modulators of the beliefs and sense of reality of hypnotized individuals rather than their actual perception.

Certain researchers conceptualize hypnotic hallucinations as authentic modulators of one's perception in a fashion vivid enough to distort the *perceived reality* of the percipient. Some of the first experimental examples supporting the perceived reality of positive hypnotic hallucinations were experiments showing that negative afterimages resulted from hypnotically induced colour hallucinations (Rosenthal & Mele, 1952)*. Before such experiments acquired solid scientific credibility, however, further investigations of the phenomenon showed that most highly suggestible participants (HSIs) reported seeing afterimages, but the colour of their afterimages they reported corresponded to the colour they expected to see rather than the colour a real afterimage would generate (Hibler, 1940). In an attempt to promote the objectivity and credibility surrounding hypnotic hallucinations, Brady and Levitt (1966) measured eye movements resulting from visual hallucinations. They showed that realistic eye nystagmus — a particular eye movement that is difficult to feign without appropriate visual stimulation — occurred when HSIs hallucinate, but not when they imagine the rotation of an optokinetic drum. Nonetheless, these results were later debated by Evans, Reich, and Orne (1972) who showed that nystagmus also occurred in awake, highly motivated subjects.

Consequently, several researchers consider hypnotic hallucinations to be mere theatrics; hypnotized subjects would report perceiving suggested stimuli (e.g., seeing a non-existent shape, hearing a suggested voice, etc.) simply as a result of

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* Participants hallucinated a colour dot that was not physically visible under suggestion. After being awakened, participants reported seeing an afterimage of the hallucinated dot.

demand characteristics (Spanos, Flynn, & Gabora, 1989; Sutcliffe, 1961). In support of this view, some studies have found that participants report vividly experiencing hypnotic suggestions while exhibiting behaviours or providing explanations that contradict their report. For example, studies on hypnotically suggested blindness have shown that even though certain participants report becoming functionally blind, they nonetheless avoid colliding into objects, and are able to report numbers or images presented to them (Spanos, 1991). Studying hypnotically induced hallucinations from this lens, it is very difficult to fully believe the report of participants. Conversely, a study by Kinnunen and colleagues (2001) reveals that hypnotized subjects are unlikely to lie when reporting their hypnotic experience. Consequently, there is no scientific consensus with regards to the influence of hypnotic hallucinations on one's perception.

To help reconcile this ambiguity, Szechtman and Woody (2007; Erik Woody & Szechtman, 2011) proposed a new model: the modulation of yedasentience or the feeling of knowing. Supported by brain imaging studies (PET and fMRI), their theory proposes that participants who are able to hallucinate when receiving a hypnotic suggestion exhibit a stronger activation of limbic areas, especially the right anterior cingulate — generally associated with motivation, affects and interoception — and a decreased activation of neocortical areas — typically associated with critical analysis (Szechtman, Woody, Bowers, & Nahmias, 1998; E. Woody & Szechtman, 2007). In other words, when hallucinators receive a suggestion to hallucinate, they relax their critical judgement and experience internal events (e.g., hearing a suggested word, seeing a suggested colour) as if those events were externally stimulated. This perspective offers an interesting idea that would reconcile the trustworthiness of the reports of hypnotized individuals with their conflicting behaviours. Beyond the modulation of yedasentience in hypnotized individuals, however, the vividness and perceived reality of hypnotic hallucinations, especially that of positive hallucinations, remain unclear. In the present study, we attempt to ascertain whether hallucinated stimuli may be vivid enough to substantially modulate a perceptual scene in hypnotized individuals.

Withdrawing information: de-automatization

A growing body of scientific literature exemplifies demonstrations of mind–body regulations in which the *removal* of perceptual elements can modulate cognition, perceptions and actions (for a review, see Kihlstrom, 1985). For example, a common research trend illustrates how hypnotic suggestions may trigger top–down control to reduce intensity or unpleasantness of pain (Rainville, Carrier, Hofbauer, Bushnell, & Duncan, 1999). Extensively studied, the effects of suggested analgesia seem to modulate the perception of pain by operating directly at the neural level of pain correlates (Rainville, Hofbauer, et al., 1999). In a similar vein, psycho-behavioural studies in which the *withdrawal* of critical information modulates performance on neurocognitive tasks have been on the rise in the past decade. Using neuropsychological tasks such as the Stroop task (Raz & Campbell, 2011; Raz et al., 2003; Raz et al., 2007), the flanker task (Iani et al., 2006), and the McGurk effect (Lifshitz, Howells, et al., 2012) in which distracting information disturbs performance, researchers have shown that a specific suggestion to ignore distractors (i.e., the semantic meaning of words; the distractor arrows; or the visual mouth movements, respectively) may allow participants to perform better on such tasks. The latter results are of great interest for the current thesis: not only do they support and document the authenticity of negative hypnotic hallucinations (i.e., suggestions to *withdraw* or *ignore* perceptual or cognitive inputs that are normally present), they also show that suggestions to *remove* critical information may derail deeply entrenched processes thought to be largely involuntary and outside conscious control (Lifshitz, Aubert-Bonn, et al., 2012).

Adding information: automatization?

Using suggestion to *withdraw* critical information may *derail automatic* processes. We wondered, therefore, whether *adding* critical information may, in certain cases, make difficult tasks more *automatic*. Empirical studies probing this question, however, do not present such convincing and converging evidence as those illustrating how *removal* may derail automaticity. Falling short of tasks able to probe the *automatization* of difficult processes, the influence of positive hypnotic suggestion — suggestions to *add* perceptual sensations in the absence of stimuli — on cognitive and perceptual processes remains obscure.

Brain imaging technologies also appear unsatisfactory in the assessment of positive hypnotic hallucinations as they seemingly measure individual differences in perception rather than the experienced hallucination itself (Szechtman et al., 1998). Consequently, most empirical studies on positive hypnotic hallucinations rely on the subjective report of participants to determine the effectiveness of the suggested hallucination. In the present study we use MoTraK, a difficult task that can become easy with the addition of minimal visual information (Aubert Bonn & Raz, present thesis - M1). We explore whether a hypnotic suggestion to add critical visual information can enhance performance and transform a difficult task into an easier, more automatic one.

Methods

Participants

Every person falls along a continuum of susceptibility to hypnotic suggestion, which can be measured with standardized scales such as the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A). Such scales provide a quantifiable rating of an individual's response to hypnotic suggestion, thus suiting hypnosis researchers who wish to select populations that are very likely or very unlikely to respond to a desired suggestion. Approximately 10–15% of individuals (Hilgard, 1965) obtain scores of 9 or higher out of a possible 12 on the HGSHS:A and are thereby referred to as highly hypnotizable or highly suggestible individuals. Capable of entering the hypnotic state, HSIs exhibit heightened compliance with suggestion (Raz & Shapiro, 2002), and seem to experience attentional and perceptual changes that would not otherwise occur under a normal state of awareness (Spiegel, Bierre, & Rootenberg, 1989; Spiegel, Cutcomb, Ren, & Pribram, 1985). Individuals obtaining scores of 3 or less on the HGSHS:A constitute low hypnotizable or less suggestible individuals (LSIs) and rarely enter the hypnotic state. As in most hypnotic studies, we recruited HSIs and LSIs to participate in the study, and expected HSIs, but not LSIs, to respond to our suggestion and perform better when completing the task under the influence of the suggestion.

We recruited participants from a pool of 500 students enrolled in psychology classes (PSYC 410: Special Topics in Neuropsychology and PSYC 180: Critical Thinking: Biases and Illusions) at McGill University, in Montréal, Québec, Canada. As part of the curriculum of these classes, students were screened for suggestibility in a hypnotic context on the HGSHS:A (Shor, Orne, & Press, 1962). Using the collected HGSHS:A scores, we recruited 36 participants: 16 HSIs scoring in the 9–12 range, and 16 LSIs scoring in the 0–3 range. All selected participants agreed to participate in exchange for course credit.

Task

The present study had two purposes: i) to test whether a hypnotic suggestion to *add visual* elements to a perceptual scene could make a difficult, *controlled* task substantially easier; and ii) to provide a more objective measurement of hypnotic hallucinations. Our task, therefore, needed to i) start out as difficult but become easy with the *addition* of simple critical elements; ii) be minimally influenced by practice; and iii) be immune to heuristics or strategies.

Considering these criteria, we used MoTraK, an online-assessment consisting of a series of adaptations of the Occluded Diamond Paradigm (ODP; Lorenceau & Shiffrar, 1992).

i) Difficult but can become easy

The ODP, a paradigm developed and documented in visual perception research (Lorenceau & Shiffrar, 1992, 1999; McDermott et al., 2001), proved ideal for our purposes as it consists of a difficult visual illusion that can become substantially easier when simple elements are added to the visual scene. In the ODP, participants indicate the direction motion (clockwise or counter-clockwise) of a diamond (i.e., a square) translating circularly on a two-dimensional plane with its corners hidden behind visual occluders. The visual occluders can be either *invisible* — their colour matching the colour of the background — or *visible* — their colour and/or contour differing from that of the background.

Perceiving the direction of motion is instantaneous and effortless with *visible* occluders (Figure 1A), while, motion detection is challenging, if not practically impossible, with *invisible* occluders (Figure 1B).

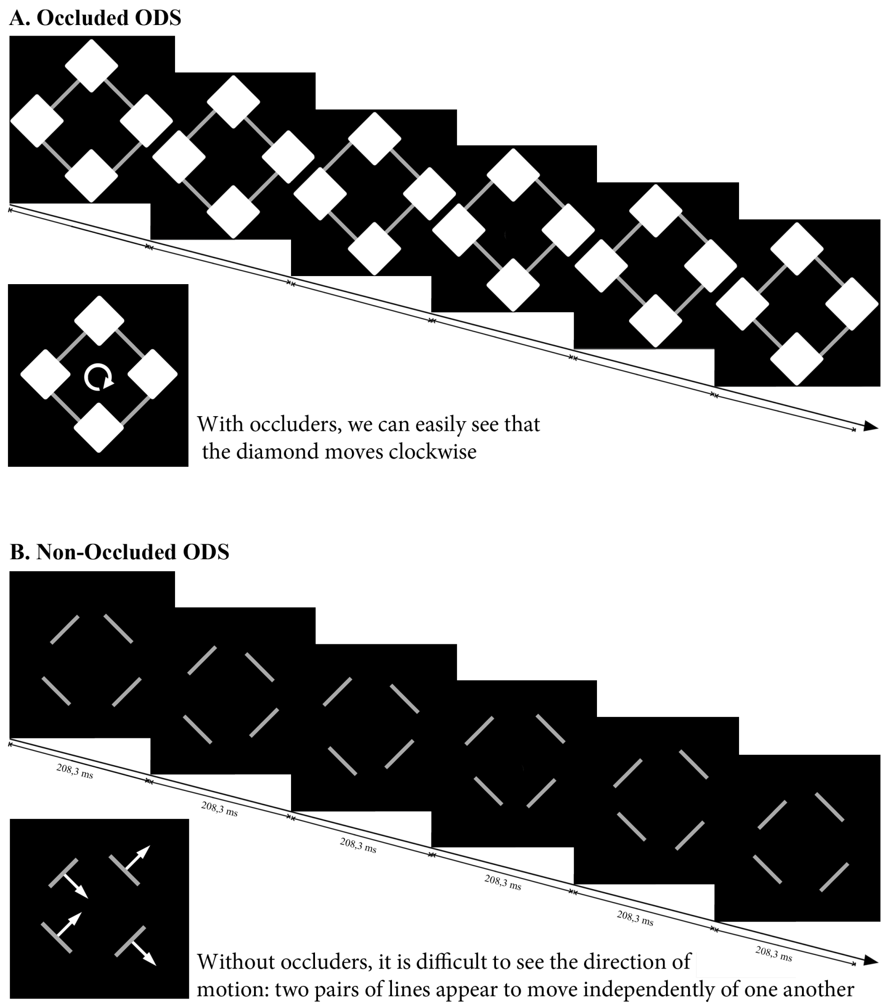

Figure 1. *The ODP is difficult, but can become easy with minimal change.* When occluders are invisible (B), determining the direction of motion (clockwise or counter-clockwise) of the revolving square is difficult. When the occluders are visible, however, (A) determining the direction of motion is effortless.

With this paradigm in mind, we built MoTraK, a 15-minute web-based Adobe® Flash® assessment that comprises 72 trials adapted from the ODP, of geometric shapes moving circularly on a two-dimensional plane. Equally divided into trials baring the shape of a square or a triangle, MoTraK included 36 square trials pseudo-randomised between 18 clockwise and 18 counter-clockwise trials, and 36 triangle trials pseudo-randomised between 12 clockwise, 12 counter-clockwise, and 12 directionless trials (i.e., the shapes increasing and decreasing in size with no particular trajectory). Preliminary explorations of MoTraK revealed that due to the difficulty the task, participants have a tendency to believe that most trials represent directionless motion. To prevent participants from focusing on directionless motion in the square trials, therefore, MoTraK always presented the triangle trials (and thus the directionless motion option) after presenting the square trials.

In MoTraK, each geometric shape revolves on a black background and is covered at its apexes by black occluders. Consequently, only four straight grey segments and three straight grey segments are visible on square and triangle trials, respectively. To discourage participants from using physical aids to substitute occluders (e.g., apposing stickers on their computer screen), we implemented a 45 and 60 degrees rotation between each trial for the squares and triangles respectively. An extended description of MoTraK is available in the first manuscript of the present thesis (Aubert Bonn & Raz, present thesis - M1).

MoTraK automatically recorded response time in milliseconds (ms) as well as accuracy (i.e., correct or incorrect) for each trial when participants pressed keys on a standard keyboard. Specifically, participants pressed the “F” key for counter-clockwise motion, the “J” key for clockwise motion, and the spacebar for directionless motion (on triangle trials only). The program displayed the stimulus of each trial without a time limit until participants responded.

To ensure participants understood MoTraK, we included interactive demonstrations of the paradigm in which participants had 15 seconds to interact with (i.e., make occluders visible or invisible) an example of a clockwise and a counter-clockwise motion prior to data collection. This interactive demonstration displayed the geometric outline of a pentagon rather than that of a square or triangle. Furthermore, we included 6 pentagon practice trials (3 clockwise and 3 counter-clockwise trials, pseudo-randomised) in which we provided accuracy feedback (i.e., "Correct" or "Incorrect"). After the practice, MoTraK automatically warned participants that they would no longer receive feedback on the following trials. Participants then underwent 36 square trials, after which MoTraK provided a 15-second interactive demonstration of a pentagon moving in a directionless motion. Participants finally completed the 36 triangle trials.

ii) Minimally influenced by practice

One of the strengths of using established cognitive tests is that they are extensively documented in the scientific literature and that their attributes, limitations, and potential applications are well known. Largely immune to practice effects, the Stroop (MacLeod, 1991), flanker (Iani et al., 2006), and McGurk (McGurk & MacDonald, 1976) effects were ideal tools to look at the *de-automatization* of automatic processes. Falling short of documented tasks that would allow us to determine whether *adding* critical elements could *streamline* difficult tasks, we built MoTraK and documented aspects of its baseline performance before using it to answer the present research questions (Results of these explorations are available in Aubert Bonn & Raz, present thesis - M1). While investigating whether our task was influenced by practice, we found that familiarity with a variation of MoTraK invisible or visible occluders did not increase accuracy on MoTraK, but that both types of prior performance reduced reaction time.

ii) Immune to heuristics and strategies

Past research supports that hypnotizability may be related to stable traits in individuals, such as attentional characteristics (Castellani, D'Alessandro, & Sebastiani, 2007; Raz, 2005; Spiegel, 2003). To ensure that the performance on MoTraK depicts the effects of hypnotic suggestion and not merely those individual differences, it was important that our task be minimally susceptible to heuristics and strategies. Semi-structured informal telephone interviews with participants revealed that most participants were unlikely to have used a mainstream strategy (Aubert Bonn & Raz, present thesis - M1), yet that a potential strategy may increase performance on MoTraK. We insist that readers should keep this limitation in mind when reading the current thesis, and that future research should identify the effects of such strategies in greater depth.

In light of these past explorations, nonetheless, we deemed MoTraK adequate and suitable to answer the present research questions.

Design

i) *Pre-assessment*

We sent an email to all potential participants (HSIs and LSIs) providing them with a Unified Resource Link (URL) of the web page hosting MoTraK and inviting them to complete the task online in a calm environment of their choice. Abridged, online consent forms informed participants of their right to withdraw from the study at any time and that information and data gathered (including response time and accuracy) could be used for scientific purposes. We gathered demographic information, including date of birth, gender, and handedness, as well as IP addresses which allowed us to identify and exclude participants who completed the task more than once. Additionally, MoTraK automatically assigned a random number (i.e., a unique completion code) to each participant. This number was required to complete the post-assessment. When completing the pre-assessment, participants were unaware that MoTraK involved a post-assessment. This experimental detail was essential to preclude from potential holdback effects (Zamansky et al., 1964).

ii) *Post-assessment*

Approximately a week after their online participation, we approached participants a second time by email and invited them to participate in the post-assessment in our laboratory. Upon arriving to the laboratory, a female experimenter greeted participants and asked them to read and sign a consent form (Appendix E) which specified that they would be undergoing a hypnotic induction. After obtaining informed consent, the experimenter escorted participants to a separate room to meet with Dr. Amir Raz, a professional hypnotist and diplomate of the American Board of Psychological Hypnosis. After explaining the scientific value and merit of hypnosis as well as its possible effects on perception, behaviour and cognition, Dr. Raz administered a hypnotic induction adapted from the Carleton University Responsiveness to Suggestion Scale (Spanos, 1983). Dr. Raz then suggested to all participants that they would be able to view the occluders while completing MoTraK, and that this would allow them to perform the task rapidly and easily (a script of the suggestion is available in Appendix F). The hypnotic induction and suggestion lasted approximately ten minutes. Following the suggestion, participants completed MoTraK a second time, under hypnosis. Upon completion of the task, Dr. Raz administered a standard hypnotic termination. The experimenter escorted participants out of the room and verbally debriefed them (view Appendix B for the hand-in debriefing form). The experimenter informally interviewed participants to determine if they had experienced particular difficulty with the task, if any instructions were unclear, and to better understand how they had experienced the post-assessment.

Results

We analysed our data using the Statistical Analysis Software (SAS® Institute, Cary, NC) version 9.2 with the MIXED procedure of repeated measures analyses of variance (ANOVA) to investigate potential differences between groups (HSIs and LSIS) and conditions (pre-assessment online and post-assessment with suggestion). MoTraK automatically recorded accuracy and reaction times (RT) on a trial-per-trial basis. Before analysing our data, we calculated average percent accuracies (for each shape in each condition) and average RTs (using only RTs of correct trials, in ms) for each participant. We thus performed our ANOVAs using four data points for each participant: squares in the pre-assessment; triangles in the pre-assessment; squares in the post-assessment; triangles in the post-assessment. We collapsed the shapes in the present analyses.

Reaction time analyses

We performed a 2 (*Hypnotizability*) x 2 (*Condition*) repeated measures ANOVA for RT and found a significant main effect of *Condition* [$F(1, 30) = 27.97$, $p < 0.0001$]. Specifically, we found that participants performed MoTraK faster in the post-assessment (i.e., after receiving the hypnotic suggestion; M = 1616 ms, SD = 678 ms) than in the pre-assessment (M = 2477 ms, SD = 1094 ms; see Figure 2). There were no interaction effects and no main effect of *Hypnotizability*.

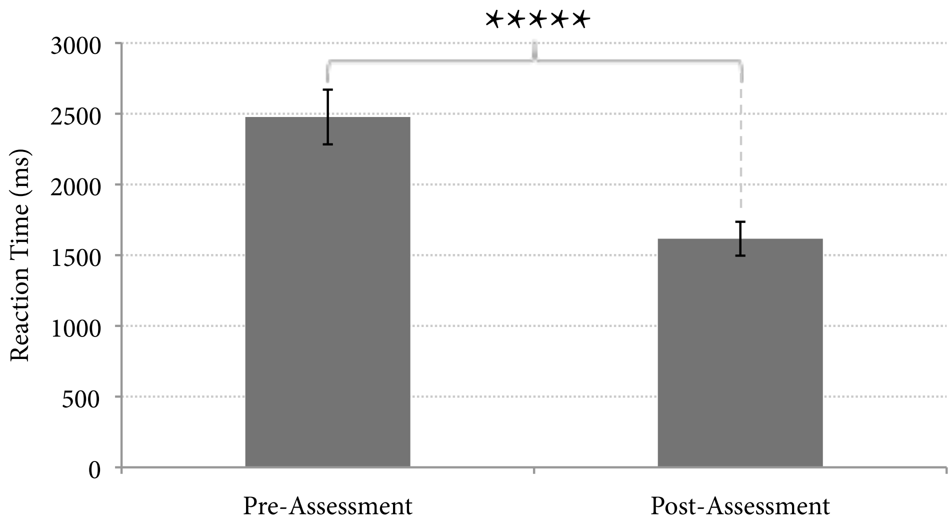

Figure 2. *Reaction time differences between conditions.* Overall, participants performed faster in the post-assessment (after receiving a suggestion) than in the pre-assessment. ***** = $p < 0.0001$; error bars represent standard errors.

Accuracy analyses

We performed a 2 (*Hypnotizability*) x 2 (*Condition*) repeated measures ANOVA for accuracy (in percent correct) and found significant main effects of both *Condition* [$F(1, 30) = 21.58$, $p < 0.0001$] and *Hypnotizability* [$F(1, 30) = 4.57$, $p < 0.05$]. Overall, accuracy was higher during the post-assessment (M = 60% accurate, SD = 29%) than during the pre-assessment (M = 41% accurate, SD = 23%). HSIs (M = 55% accurate, SD = 29%) were more accurate than LSIs (M = 46% accurate, SD = 27%).

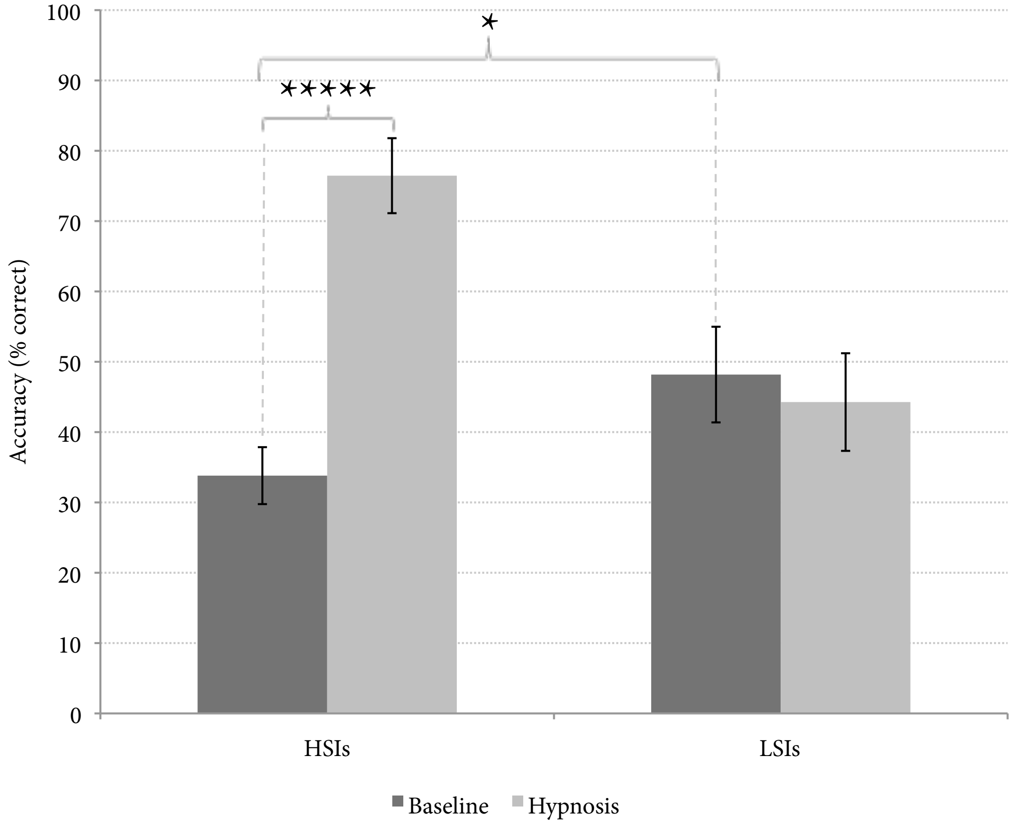

Figure 3. *Percent accuracy of each groups in each condition.* In the pre-assessment (baseline), HSIs performed a little less accurately than LSIs. HSIs, unlike LSIs, were significantly more accurate in the post-assessment (after receiving the suggestion) than in the pre-assessment. * = p < 0.05; ***** = p < 0.0001; error bars represent standard errors.

Of greater interest to us, we also found a significant *interaction* between Condition and Hypnotizability [F (1, 30) = 27.97, p < 0.0001]. Post-hoc LSD t-tests revealed that, while LSIs did not increase their accuracy, HSIs were more accurate after receiving the suggestion (M = 76% accurate, SD = 21%) than in the pre-assessment (M = 34% accurate, SD = 16%; t(30) = 7.23, p < 0.0001). Intriguingly, LSIs were more accurate than HSIs in the pre-assessment (M = 48% accurate, SD = 27%; t(30) = -2.44, p < 0.05). Interaction results are available on Figure 3. Limitations

Keeping in mind the limitations involved in the past explorations of MoTraK (Results of these explorations are available in Aubert Bonn & Raz, present thesis -

M1), the present study involved a few additional limitations. In experimental hypnosis, researchers commonly use standardized hypnotizability scales to separate participants into groups of HSIs, LSIs, and of medium susceptibility. Separating our population into HSIs and LSIs using the HGSHS:A indices (scores of 0–3 for LSIs and 9–12 for HSIs), however, we acknowledge that representativeness of our findings may be limited.

First, as most clinicians will argue, it is important to differentiate between what standardized hypnosis scales tell us about the hypnotizability of participants and how hypnotizable the participant truly is (Spiegel, 2010). Although hypnotizability scales indicate that LSIs are less likely to enter the hypnotic state than HSIs, they "only predict responses to hypnosis about 50% of the time" (Barabasz & Christensen, 2010). As a result, while we established our hypotheses and interpreted our data with the assumption that HSIs, but not LSIs, entered the hypnotic state, there is a slight possibility that some HSIs did not enter the hypnotic state while some LSIs did. Should that be the case, the difference in performance observed between the groups would not be a pure estimate of the efficacy of the hypnotic suggestion but a combined estimate of the efficacy of the hypnotic suggestion and group variations.

Second, differences between HSIs and LSIs in the pre-assessment of MoTraK may limit the conclusions we can draw from the accuracy and RT differences observed in the post-assessment. While we cannot fully explain the baseline difference between HSIs and LSIs, past studies intimate that HSIs differ from LSIs in at least some of their attentional networks (Castellani et al., 2007). Specifically, the alerting attentional network — principally responsible for maintaining a state of alertness and sensitivity to incoming stimuli — appears to be lower in HSIs than in LSIs. Considering that MoTraK is looking at motion perception, in which little (Treisman, 1985), yet some (Raymond, 2000) attention is required, this dissimilarity may come into play and disproportionally affect the performance of HSIs and LSIs. Future studies should investigate the relationship between hypnotizability indices and performance on MoTraK in the absence of any suggestion.

Third, we did not include the shapes in our analyses because the focus of the present study was not to investigate possible differences between the geometrical shapes used in MoTraK. In previous documentation of MoTraK, however, we have shown that participants tend to be less accurate on the squares than on the triangles (Aubert Bonn & Raz, present thesis - M1). Further investigations including possible interaction effects of shape may be necessary to fully grasp how visual hallucinations influence performance.

Fourth, we acknowledge that counterbalancing the conditions (i.e., starting with the hypnotic suggestion condition and repeating the MoTraK without suggestion in the post assessment) would have strengthened the conclusions we could draw from our investigations by precluding practice effects. Nonetheless, preliminary testing revealed that participants were unable to grasp the task when the hypnotic suggestion condition was administered first. Introducing demonstrations of MoTraK and practice trials before the administration of the hypnotic suggestion may help resolve this methodological drawback.

Fifth, although it is possible to employ certain techniques to see the direction of motion in the ODP (e.g., looking in the periphery, blurring one's eyes, apposing visible occluders, etc.), we took several measures to prevent these techniques. For example, we implemented a 45 and 60 degrees rotation between each square and triangle trials, respectively, to prevent the placement of physical occluders on the computer screen (e.g., sticky notes). In addition, experimenters monitored all participants that completed MoTraK in the lab, making sure that they sat straight in front of the screen and that they did not squint their eyes. Previous exploration of MoTraK revealed that, despite the lack of monitoring in the pre-assessment, setting (i.e., performing MoTraK in the lab or online) did not influence performance (Aubert Bonn & Raz, present thesis - M1). Alternatively, some may propose that the increased performance in HSIs is due to alterations of the visual acuity (e.g., blurring) of hypnotized participants rather than the hallucinated shapes. In fact, blurring the ODP, or looking at it from the periphery (i.e., using a section of the retina that is not as sensitive as the fovea) increases the perceived cohesiveness of the moving shape and helps participants see the direction of motion (Lorenceau & Shiffrar, 1999). Even though our results cannot rule out the possibility that the hypnotic suggestion dampened the visual acuity of HSIs, Stroop studies using pharmaceutical agents to induce cyclopegia — paralysis of the ciliary muscles of the eye — showed that effects of suggestion go beyond superficial blurring of the eyes (Raz et al., 2003). Further skeptics may propose, in line with past neuroimaging investigations, that increased performance on MoTraK may result from an early dampening of visual information that would not be influenced by artificial cyclopegia (Raz et al., 2005). If this were the case, increased accuracies in HSIs might not depict successful positive hallucinations, but rather represent simple hypnotic and visual artifacts. Nonetheless, further investigations on the reduction of Stroop interference showed that hypnotic suggestion to view the words as meaningless symbols hardly affected negative priming (Raz & Campbell, 2011), thereby proposing that early dampening of visual information is unlikely to fully explain the phenomenon; participants could most likely still see the letters crisply. Further studies would need to investigate whether our hypnotic suggestion generally dampens or rather triggers specific visual areas of the brain to better understand the efficacy of the hallucination and the potential influence of our hypnotic suggestion on the visual system.

Sixth, due to the nature of the suggestion, we experienced some complications with certain participants. For example, two of the HSI participants preferred enunciating the direction of motion rather than pressing the keys on the keyboard. They asked Dr. Raz to press the keys on the keyboard as they orally expressed "clockwise", "counter-clockwise", or "directionless". The concern with this procedural difficulty is that it may have artificially slowed post-assessment RT for these two individuals. Future investigations on MoTraK could use systems such as voice monitored RT recording to avoid this difficulty. Furthermore, although we hoped that the informal interviews conducted with the participants after the post-assessment could help us understand their perceptual experience, at least three HSI participants seemed to have experienced post-hypnotic amnesia, denying even having completed MoTraK a second time. Using a post-hypnotic suggestion — a suggestion that comes into effect after the hypnotic termination, while the participant is in a normal state of wakefulness — instead of a hypnotic suggestion could help solve both of these problems.

Discussion

Three results are worthy of discussion. First, it is interesting to note that HSIs were less accurate than LSIs at baseline. This finding may indicate that HSIs respond differently to MoTraK than LSIs, a finding that is particularly interesting as HSIs have been found to differ from LSIs on several cognitive functions such as attention (Castellani et al., 2007). Most interestingly, the fact that HSIs perform below expected chance levels at baseline proposes that they may use a certain answering pattern or strategy in answering. Our populations being too small to allow us to conclude that the difference between HSIs and LSIs is attributable to hypnotizability or to HSIs' greater adherence to answering patterns, we strongly encourage future studies to look at MoTraK on larger populations of HSIs and LSIs to locate these baseline distinctions.

Second, without occluders, MoTraK is difficult. Improved accuracy under hypnotic suggestion supports the notion that HSIs, unlike LSIs, may have successfully envisaged the occluders. Informal interviews following the experiment further support this finding; LSIs were unable to envision the occluders whereas multiple HSIs reported having seen or partially seen occluders. Nonetheless, a thorough investigation of potential strategies used on MoTraK would be crucial to allow us to understand whether higher accuracies in the post-assessment of HSIs are due to genuine visual hallucination of MoTraK occluders or merely a faster implementation of answering strategies.

Finally, based on past investigations of MoTraK (Aubert Bonn & Raz, present thesis - M1), it seems likely that RT decreases in the post-assessment were due to familiarity with the task rather than to the influence of suggestion.

Suggested versus visible occluders

Comparing the performance of HSIs who received a hypnotic suggestion to view the occluders to that of individuals performing MoTraK with real, visible occluders (Aubert Bonn & Raz, present thesis - M1), our results show that even though HSIs substantially increased their accuracy after receiving a hypnotic suggestion to hallucinate occluders (from 34% correct answers in the pre-assessment to 76% after receiving the suggestion), they did not perform as well as participants who completed a version of MoTraK with visible occluders (96% correct). Several possibilities may explain this interesting finding.

First, it is possible that our suggestion was not fully effective in achieving its goal. In fact, some HSIs reported that even though they responded to the hypnotic suggestion, the hallucination they experienced only allowed them to envisage incomplete or transient visions of occluders. In this case, it is possible that the specific wording of the suggestion, as well as the broadness of the hypnotizability indices included in our population of HSIs prevented the suggestion from exerting a full effect. Nonetheless, it is also possible that the hypnotic suggestion itself, even when fully effective, acted as a facilitator or an aid rather than as a full modulator of one's perception. Further investigations, including full interviews with the participants should clarify this idea.

Second, and most importantly, the hypnosis literature suggests a difference between HSIs and hallucinators (Szechtman et al., 1998; E. Woody & Szechtman, 2007). While hypnotizability scores measured using standardized scales seem to correlate with the ability of individuals to enter the hypnotic state (Shor et al., 1962; Weitzenhoffer & Hilgard, 1962), they indicate very little concerning the types of suggestions participants will respond to (E. Woody, 2012). In fact, the HGSHS:A contains a wide range of *Motor* items and is thereby quite representative of responsiveness to motor-behavioural suggestions, yet it only contains two partial *Perceptual-Cognitive* items (i.e., items assessing the responsiveness to hypnotic suggestion affecting perceptual changes, such as hypnotic hallucinations).

Strengthened by the fact that it is administered in groups, the HGSHS:A is an excellent tool in research as it maximizes the ecological uniformity associated with the scores it yields. Nevertheless, the HGSHS:A may be ill-suited to determine whether participants are able to hallucinate (E. Woody, Barnier, & McConkey, 2005). Using the HGSHS:A as inclusion criteria in the present study, therefore, may have increased the odds of including non-hallucinators in our population of HSIs and may explain the moderate increase in performance observed in HSIs. Using a scale containing more *Perceptual-Cognitive* items such as the Stanford Hypnotic Susceptibility Scale: Form C (Weitzenhoffer & Hilgard, 1962) or specially tailored scales (E. Woody et al., 2005) to select future participants may result in a more precise selection of hallucinators and help us better assess the efficacy of the suggestion itself.

Adding information and automaticity

Our results bring up an important notion and can help us answer the two questions we posed earlier.

First, can a hypnotic suggestion to *add* critical information render difficult task automatic? We remember that a suggestion to *withdraw* critical information from a perceptual scene could disrupt the automaticity of certain processes and bring them back under conscious control (Iani et al., 2006; Lifshitz, Howells, et al., 2012; Raz, Fan, & Posner, 2006; Raz et al., 2007). Here we show that the opposite may also be true: using hypnotic suggestion to *add* critical information may, in specific cases, transform a difficult task into an easier, more automatic one. Further investigation is needed to enlighten whether this increased ease may reach full automatization.

Second, MoTraK adds a new perspective to the debate on the perceived reality and vividness of hypnotic hallucinations. While more objective measures, such as eye tracking technologies, would help further resolve this question, our results propose that a hypnotic suggestion to hallucinate visual shapes is sufficient to boost performance of HSIs on a task that is, without visual occluders, extremely difficult. Whether or not HSIs vividly hallucinated the visual occluders is difficult to confirm, yet the combination of i) their increased accuracies and ii) their reports encourage us to believe that they vividly experienced the hallucination as a modulation of their perception.

The present findings on MoTraK expand beyond hypnosis and visual research and breach into the territory of health practices. We have known for many years that the *body* and the so-called *mind* (thoughts, cognition, emotions) of an individual are in constant interaction with one another. While a bodily generated process may trigger particular thoughts, emotions, or actions, the reverse is also true. The study of mind–body interactions is essential because those interactions allow us to identify key elements of healing and to better understand health and diseases. Health may be conceived in two different ways: i) one in which health is the absence of illness or disease; ii) the other in which health is the constant maintenance and re-adaptation of the full internal and external organism homeostasis, an active process to fight diseases. If we embrace the former conception of health, we would understand healing processes as the withdrawal or removal of pathologies from one's system. In this case, investigating how top–down modulations may *remove* critical elements would be a suitable model to better understand healing processes and mind–body modulators of health. Here, however, we propose that the second conception of health is much more accurate considering the current knowledge of medicine and physiology (WHO, 1946)[†]. While the former view affords an interesting philosophical perspective, healing processes have often been shown to result from the *introduction* and *provocation* of complex physiological reactions. From this perspective, therefore, we think that an appropriate understanding of top–down *activations* (e.g., positive hypnotic hallucinations) is necessary to grasp the mechanisms behind healing and other mind–body interactions such as placebo effects. In fact, placebo effects, including placebo analgesia, have been shown to *trigger* complex bodily reactions (e.g., hormonal discharges) to counter diseases or noxious stimuli rather than simply *decrease* brain activities to hinder or minimize the sensation associated with harmful stimuli (Amanzio & Benedetti, 1999). By showing that a suggestion to *add* critical visual occluders to a perceptual scene could make amenable individuals perform more accurately on an otherwise difficult task, our findings support the idea that top–down modulations may affect one's perception without requiring real, tangible stimuli. A better understanding of what modulates such interactions, including how consciousness, volition, and expectations (rather than deceptive beliefs) influence the strength of top–down effects is likely to be the next step in this blossoming field of research. MoTraK may, therefore, give us preliminary insights that will help pave the road to elucidate modulators of health and disease.

[†]The WHO defines health as "A state of complete physical, mental, and social well being, and not merely the absence of disease and infirmity."

Connecting Ideas: Manuscript Three

This final manuscript puts forth most of the results presented in Manuscript Three, but is intended to be published as a short communication in a higher impact journal. Despite its conciseness, this short piece proved to be the most challenging manuscript to write among the present thesis. Every word had to clearly convey to the reader the ideas, goals, methods and results of our project, all the while remaining coherent, intelligible, and accurate. Its relevance in the present thesis goes without saying as it affords a quick, but precise reading of our most important findings.

Manuscript Three

Suggesting critical visual information transforms difficult into easy

Noémie Aubert Bonn*, Alexandra Fischer†, & Amir Raz*

Departments of Psychiatry* and Psychology†, McGill University, Montreal, QC, H3W 1E4, Canada.

One sentence summary

Suggesting the presence of critical visual information renders a challenging perceptual task easier.

Abstract

Removing visual information using suggestion has been shown to influence cognitive and perceptual processing. We explored whether adding visual information using suggestion would render an otherwise effortful task easier. Here we show that suggesting the addition of critical information instigates fast and accurate performance on a visual task.

Keywords: *MoTraK; visual hallucination; hypnotic suggestion; top–down modulation; automaticity*

Main text

Can a simple suggestion to add or remove critical information metamorphose an effortful task into an effortless one? (See razlab.mcgill.ca/thesis_aubertbonn.html*)

Easy perceptual tasks can become difficult when critical information is missing (Lorenceau & Shiffrar, 1992; McDermott et al., 2001) . A mere suggestion to remove such information can lead some individuals to behave as if it is not there, thus allowing them to override certain automatic processes (e.g., reading for a proficient reader; Raz et al., 2005; Raz & Shapiro, 2002). Such top–down influence typifies the regulation by higher cognitive systems of bottom–up sensory mechanisms. Here we tested whether a hypnotic suggestion to add information — i.e., the presence of critical visual occluders — would propel highly suggestible individuals (HSIs) to improve their performance on an otherwise difficult task.

The Interactive Movie available at razlab.mcgill.ca/thesis_aubertbonn.html* showcases this task wherein participants look at moving geometric figures with invisible corners and identify the direction of motion (e.g., cockwise or counterclockwise; McDermott et al., 2001). Without visible occluders, perceiving the direction of motion is challenging. (See Figure 1A). When occluders are present however, motion detection becomes instantaneous and effortless (Figure 1A).

Pre-screened for hypnotic suggestibility (Shor et al., 1962), participants included 16 HSIs and 16 less-suggestible individuals (LSIs). Emphasizing both

* Please email Noémie Aubert Bonn, the author of the present thesis, to have access to the online movie. Email: noemie.aubertbonn@mail.mcgill.ca

speed and accuracy to all participants, a computer program introduced the task using a quick interactive demonstration featuring trials with and without occluders. The program recorded reaction time and accuracy on six training trials providing feedback (correct or incorrect), followed by 72 experimental trials containing neither feedback nor occluders. In the suggestion condition, all participants received a brief live hypnotic induction followed by a suggestion to see occluders masking the corners. We hypothesized that HSIs, compared to LSIs, would elicit faster RT and higher accuracy as a function of this suggestion.

Exploration of the task revealed three important findings: 1. no familiarity effects of accuracy (i.e., faster reaction times but comparable accuracy across two consecutive sessions in 40 individuals); 2. performing the task in the presence of real (visible) occluders resulted in near-perfect accuracy (N=120; M=95% correct); and 3. counterbalancing the experimental conditions (i.e., with versus without suggestion) was impractical because participants had great difficulty grasping the task when the suggestion condition occurred first preceded only by trials that were devoid of real occluders. Accordingly, we tested participants under two conditions: first at baseline (i.e., no suggestion) and then with a specific suggestion to see occluders covering the otherwise invisible corners.

Analyses of variance yielded a significant interaction between condition and hypnotizability [$F(1, 30) = 27.97$, $p < 0.0001$]. Specifically, compared to baseline, HSIs performed faster ($t(30) = -4.30$; $p < 0.0001$) and more accurately ($t(30) = 7.23$; $p < 0.0001$) under suggestion (Figure 1B). The accuracy of LSIs was comparable regardless of suggestion, but their RT was faster under suggestion ($t(30) = -4.10$; $p < 0.001$). Without occluders the task was difficult; improved accuracy and faster RT under suggestion, therefore, support the notion that HSIs, unlike LSIs, may have successfully envisaged the occluders. The faster RT of LSIs under suggestion proposes that they likely were able to comply only with the exhortation to perform the task speedily. Accuracy findings intimate, however, that LSIs were unable to see the occluders. Informal interviews following the experiment further support these findings: LSIs were unable to envision the occluders whereas multiple HSIs reported having seen them.

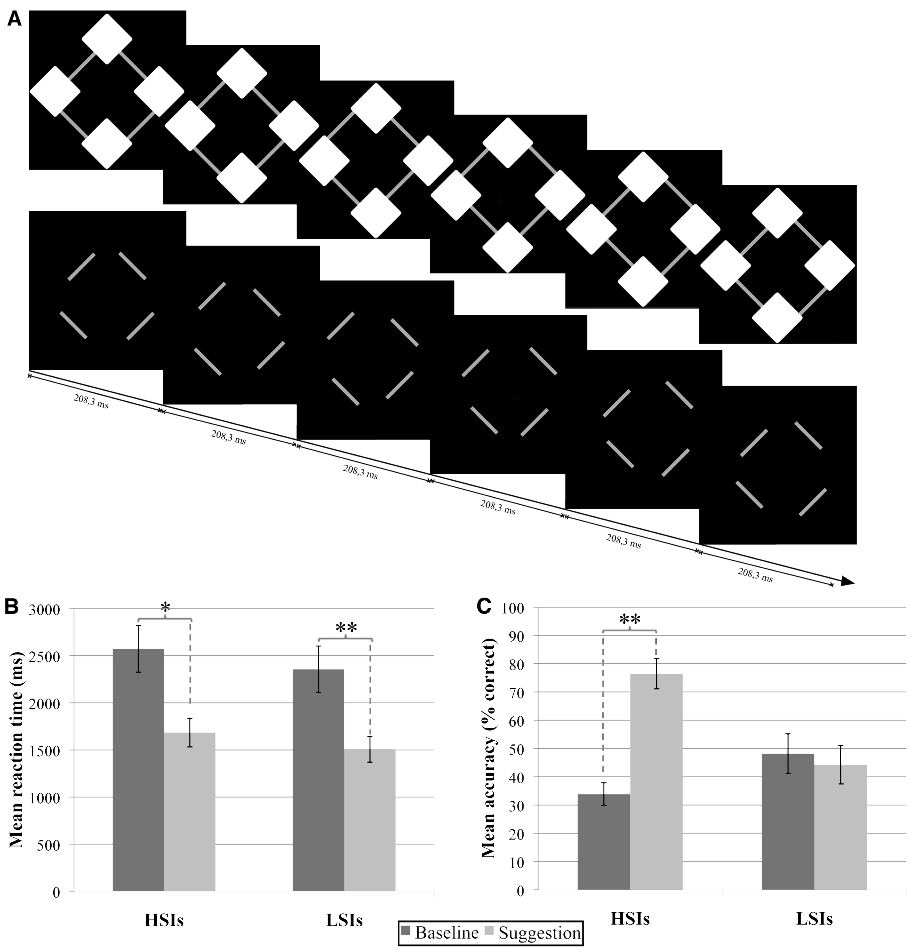

Figure 1. *MoTraK and the ODP.* (A) A square moving clockwise with visible and invisible occluders, respectively (B) Mean reaction time. (C) Mean accuracy.
*: $p < 0.001$; **: $p < 0.0001$; error bars represent standard errors

Here we show that for HSIs, hypnotic suggestion to see non-existent occluders may improve RT and accuracy on a challenging visual task. Our findings support the notion that top–down influence, powered by a suggestion to add visual information to a display, can streamline bottom–up processes driven by sensory input. Beyond replication, future studies should explore whether practice may interact with suggestion to result in a motivational “try harder” instruction for all participants but that affects HSIs disproportionately. Paving the road to a more scientific understanding of suggestion will likely elucidate mind–body phenomena, including the mechanisms subserving the influence of symbolic thinking, expectations, and placebo effects.

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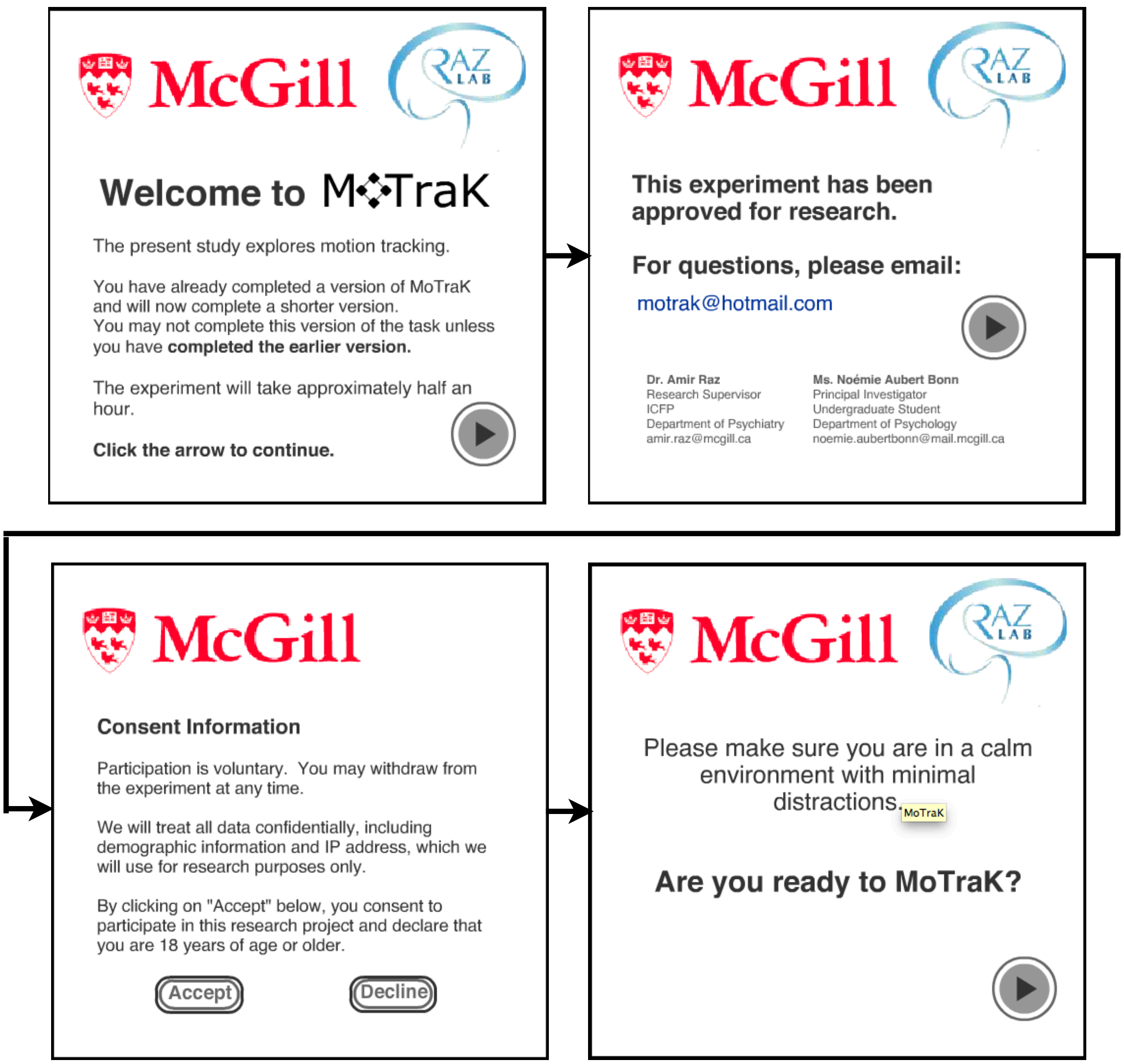
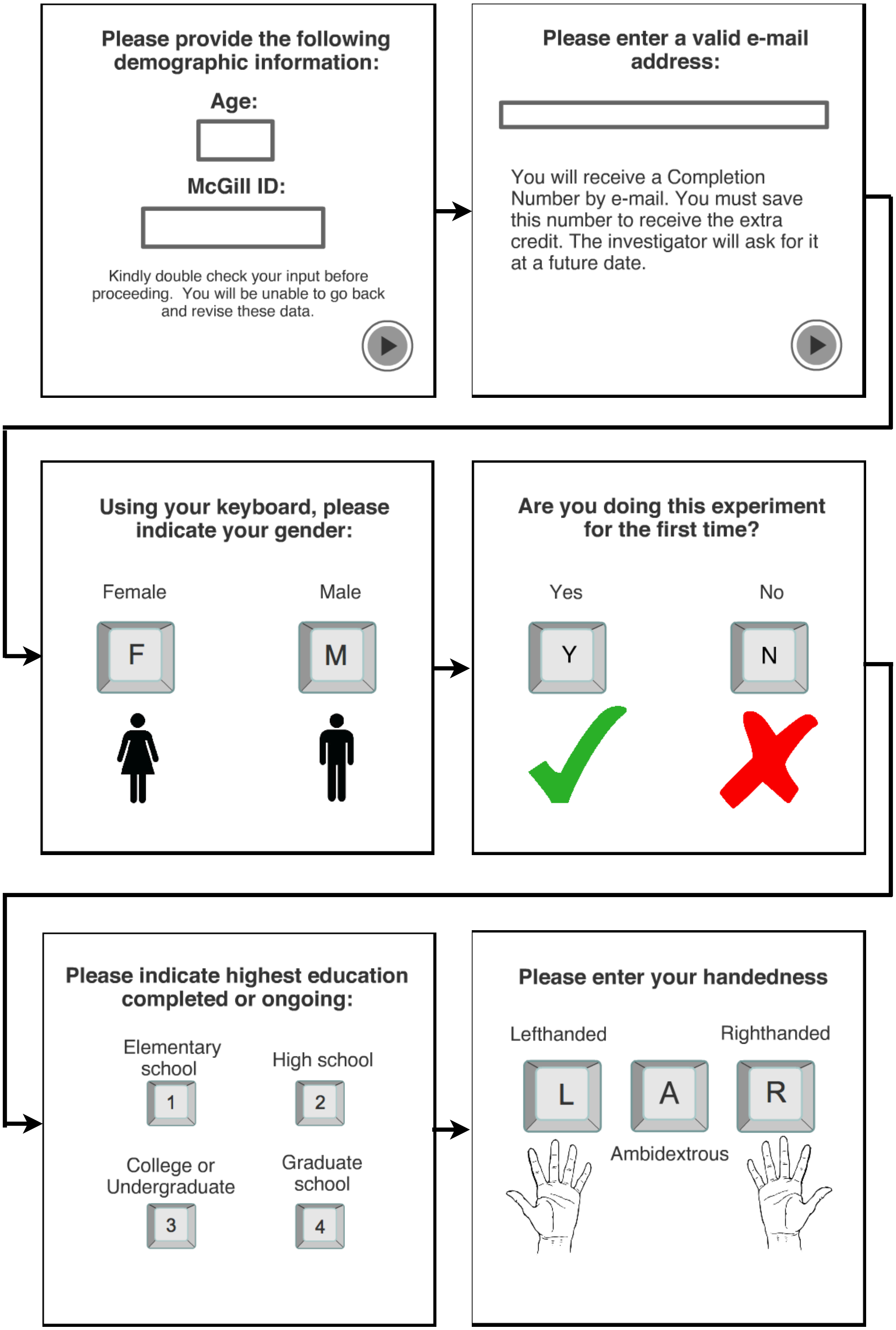
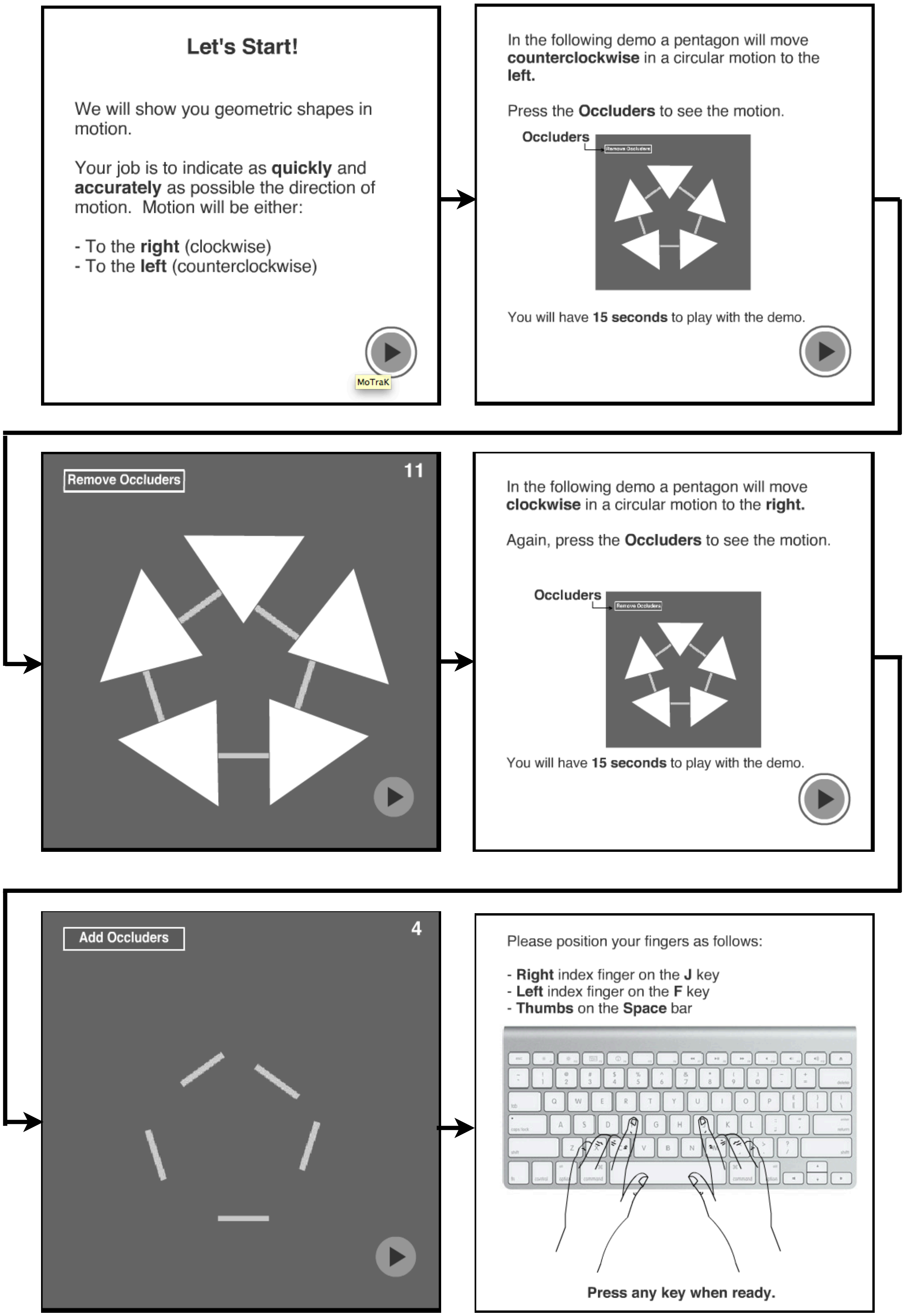
Appendix A

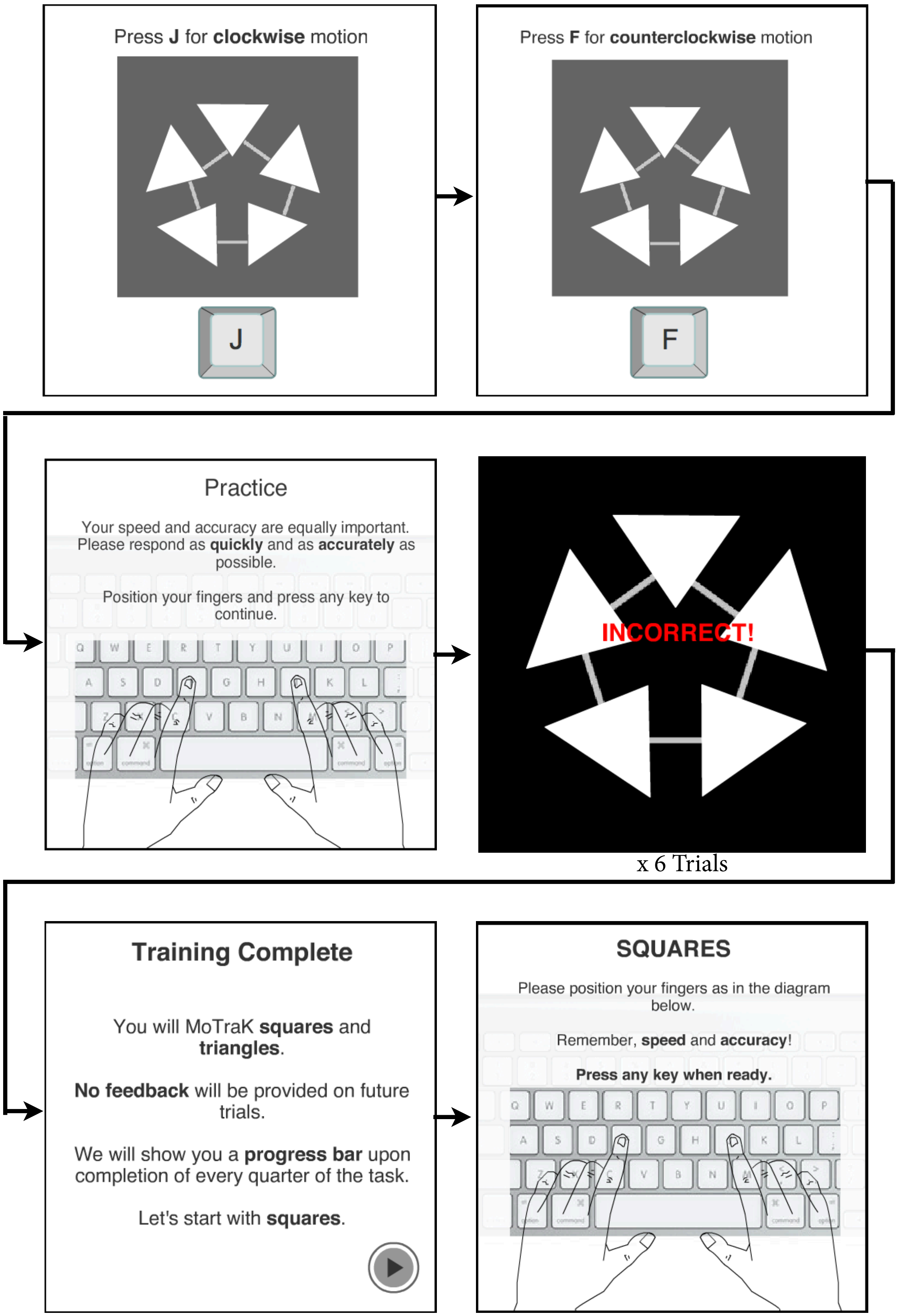
Chronological frame representation of MoTraK

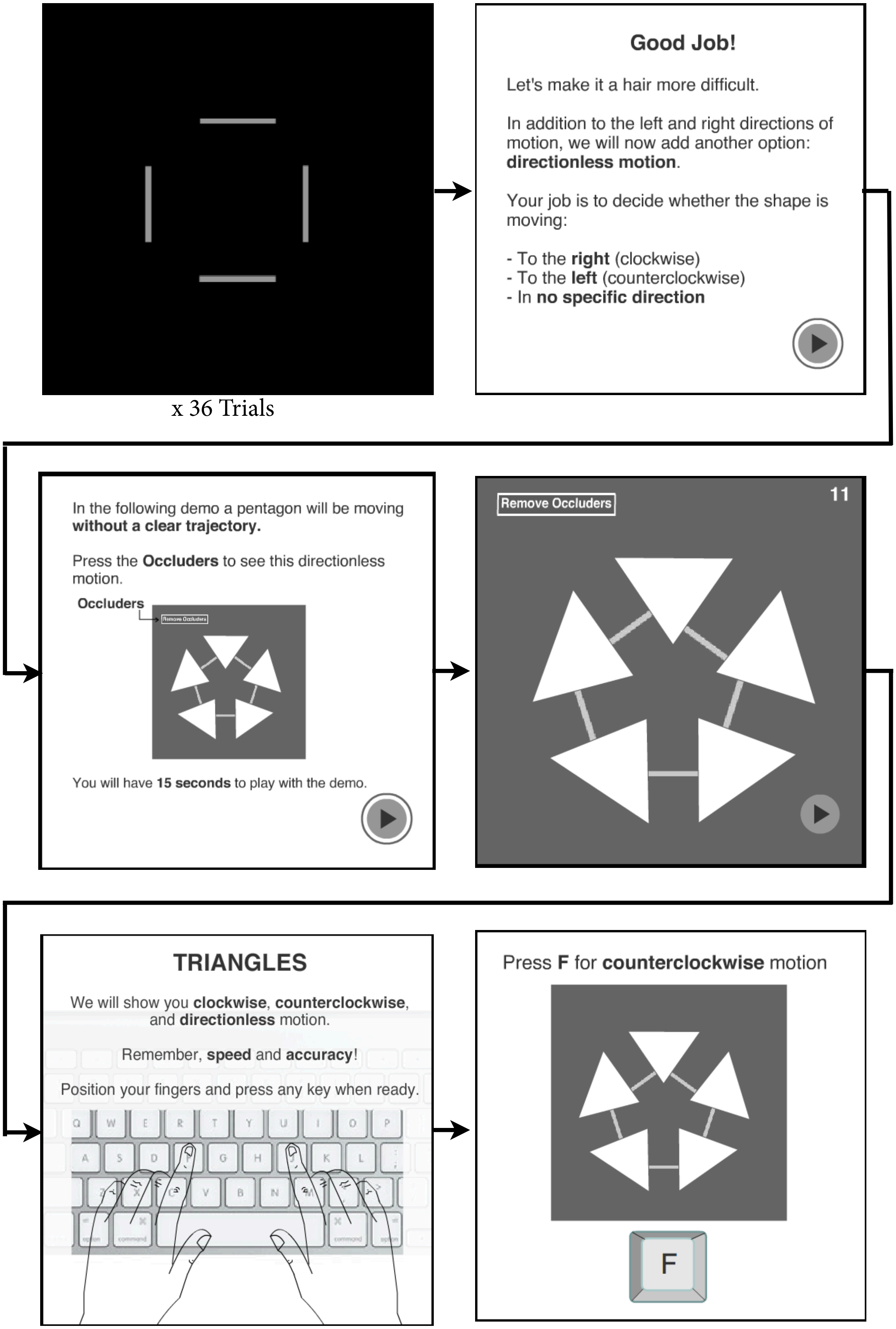
The following represents the order of events in a pre-assessment of MoTraK. Each image is a screen capture of the information MoTraK displays to participant. Images range chronologically from the upper left of each page to the bottom right, then back to the upper left of the following page.

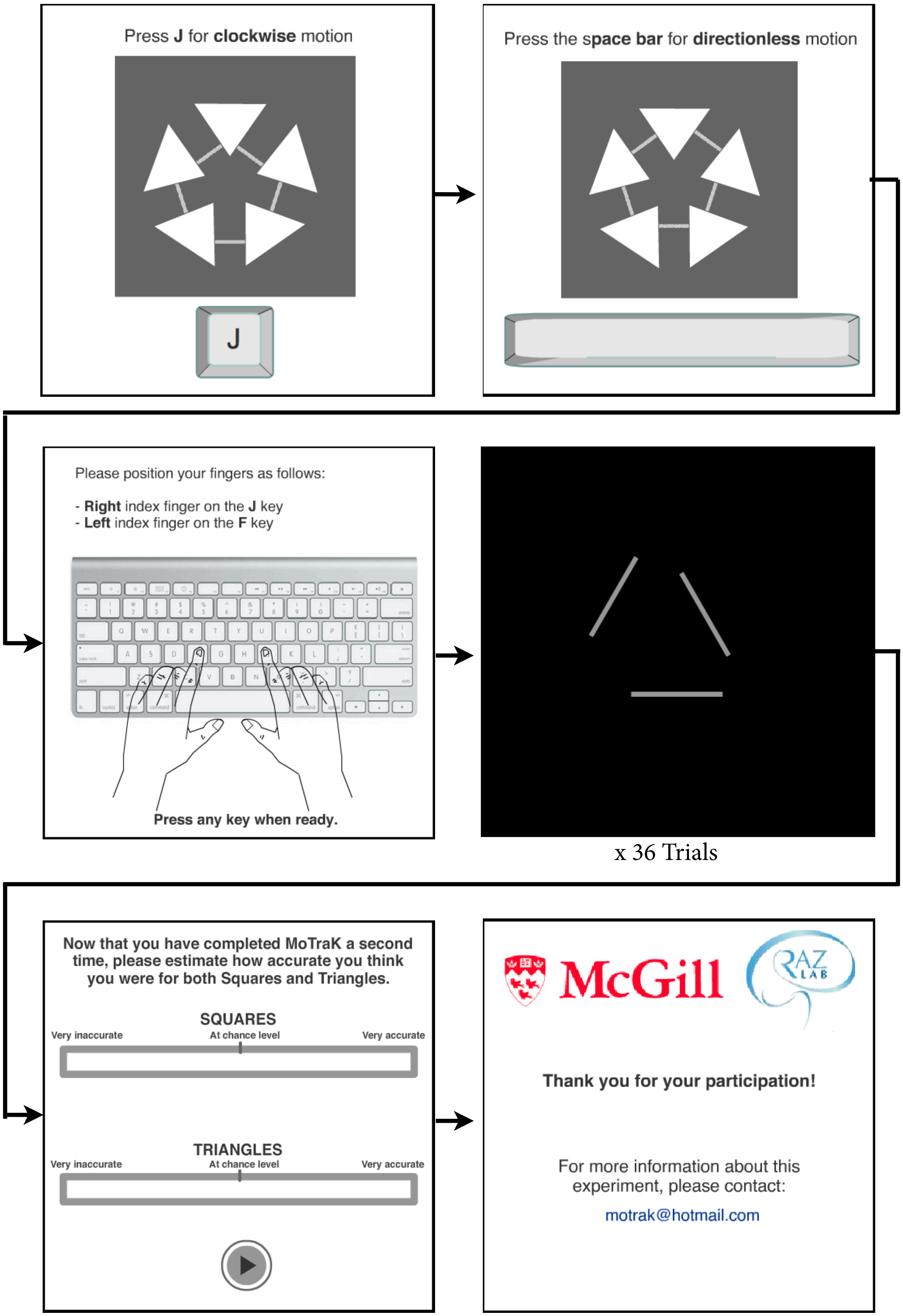



Please provide the following demographic information:
Age:
McGill ID:
Kindly double check your input before proceeding. You will be unable to go back and revise these data.
Please enter a valid e-mail address:
You will receive a Completion Number by e-mail. You must save this number to receive the extra credit. The investigator will ask for it at a future date.
Using your keyboard, please indicate your gender:
Female
Male
F
M
Are you doing this experiment for the first time?
Yes
No
Y
N
Please indicate highest education completed or ongoing:
Elementary school
High school
1
2
College or Undergraduate
Graduate school
3
4
Please enter your handedness
Lefthanded
Righthanded
L
A
R
Ambidextrous


Let's Start!
We will show you geometric shapes in motion.
Your job is to indicate as quickly and accurately as possible the direction of motion. Motion will be either:
- To the right (clockwise)
- To the left (counterclockwise)
MoTraK
In the following demo a pentagon will move counterclockwise in a circular motion to the left.
Press the Occluders to see the motion.
Occluders
You will have 15 seconds to play with the demo.
Remove Occluders
11
In the following demo a pentagon will move clockwise in a circular motion to the right.
Again, press the Occluders to see the motion.
Occluders
You will have 15 seconds to play with the demo.
Add Occluders
4
Please position your fingers as follows:
- Right index finger on the J key
- Left index finger on the F key
- Thumbs on the Space bar
Press any key when ready.


Press J for clockwise motion
J
Press F for counterclockwise motion
F
Practice
Your speed and accuracy are equally important. Please respond as quickly and as accurately as possible.
Position your fingers and press any key to continue.
INCORRECT!
x 6 Trials
Training Complete
You will MoTraK squares and triangles.
No feedback will be provided on future trials.
We will show you a progress bar upon completion of every quarter of the task.
Let's start with squares.
SQUARES
Please position your fingers as in the diagram below.
Remember, speed and accuracy!
Press any key when ready.


x 36 Trials
Good Job!
Let's make it a hair more difficult.
In addition to the left and right directions of motion, we will now add another option: **directionless motion**.
Your job is to decide whether the shape is moving:
- To the **right** (clockwise)
- To the **left** (counterclockwise)
- In **no specific direction**
In the following demo a pentagon will be moving **without a clear trajectory.**
Press the **Occluders** to see this directionless motion.
Occluders
You will have **15 seconds** to play with the demo.
Remove Occluders
11
TRIANGLES
We will show you **clockwise**, **counterclockwise**, and **directionless** motion.
Remember, **speed** and **accuracy**!
Position your fingers and press any key when ready.
Press **F** for **counterclockwise** motion
F


Press J for clockwise motion
J
Press the space bar for directionless motion
Please position your fingers as follows:
- Right index finger on the J key
- Left index finger on the F key
Press any key when ready.
x 36 Trials
Now that you have completed MoTraK a second time, please estimate how accurate you think you were for both Squares and Triangles.
SQUARES
Very inaccurate
At chance level
Very accurate
TRIANGLES
Very inaccurate
At chance level
Very accurate
McGill
RAZ LAB
Thank you for your participation!
For more information about this experiment, please contact:
motrak@hotmail.com

Appendix B

Debriefing form

Debriefing Form
Experiment on Hypnotic Susceptibility and the Occluded Diamond Task
McGill University

Principle Investigator:
Alexandra Fischer
Department of Psychology, McGill University
Alexandra.fischer@mail.mcgill.ca

Supervisor:
Dr. Amir Raz
Department of Psychiatry, Neurology and Neurosurgery, and Psychology, McGill University
Canada Research Chair in the Cognitive Neuroscience of Attention
McGill University and SMBD Jewish General Hospital
amir.raz@mcgill.ca
(514) 340-8222 ex. 7923

Thank you for participating in our study. You have taken part in an experiment testing the effects of hypnotic suggestion on motion perception. You completed MoTrak on two occasions: with and without hypnotic suggestion.

MoTraK is a motion perception task that tests your ability to accurately and quickly detect the direction of motion of a geometric shape occluded at the corners. Previous experiments have shown that coherence of motion is significantly diminished in occluded geometrical shapes, when the occluded regions are invisible. In such tasks when perception of motion is impaired, participants perform with decreased accuracy and increased response time.

A hypnosis induction and suggestion were administered to observe their effects on your perception of the task. Previous experiments have shown hypnosis leads to a state of focused attention and that suggestions administered during this state can bring about perceptual changes in highly hypnotizable individuals. We hypothesize that a hypnotic suggestion to view occluders on MoTraK trials will enable participants to see the direction of motion of the geometrical shape. We expect highly hypnotizable individuals to perform the task with increased accuracy and speed compared to low hypnotizable individuals.

If you have any questions or concerns about your participation in this study, please contact Alexandra Fischer at the e-mail address provided above.

Appendix C

Informal interview guide

Qualitative Question:

How do participants who obtained extreme scores explain their performance on MoTraK?

> *This interview guide contains several questions and should be used to orient the ideas of the interviewer. The interviewer should not use this guide in a «questionnaire fashion», but rather as an inspirational guide to make sure she/he covered all the information necessary for a rich and complete perception of the interviewee's experience.*

Greetings + Thank you for accepting to join me for this interview, etc.

Ok. We'll start by talking about your MoTraK experience. So you came in last DATE to do MoTraK. Do you remember your experience pretty well?

> *Knowing whether the participant remembers the experience will help me determine the validity of the interview.*

Can you explain to me what you did?

> *Let time for the participant to talk about the experience. Try to pay attention to her/his vocabulary and refer to it later on. Try to seek for clues indicating whether the participant found a particular strategy for performing the task.*
>
> *Follow to the questions to cover what the participant did not cover in depth.*

How do you think you did on the task?

> *In previous investigation about my task, I have found that performance is not always correlated with perceived accuracy, in other words, people are not accurate at estimating how accurate they were on the task. This information may be an indicative of the strength of conviction the patient may have in his or her strategies.*

What portion of the task did you find the hardest/easiest? What made it hard/easy?

> *To gather general information on their performance.*

Did you use a particular strategy of did you find a trick that helped you on the task?

> *If they describe a different technique, unrelated to the hallucination, I have to make them extrapolate, describe this technique further (e.g., motion algorithm, blurring their eyes, etc.).*

Thank you for accepting to join me for this interview, etc.

Appendix D

Average Accuracy and Reaction Time for Each Group in the Pre- and the Post-Assessment

			Accuracy (% correct)		Reaction Time (ms)	
Group	**N**	**Assessment**	Mean	SD	Mean	SD
1	94	Pre	36	23	2432	1374
2	49	Pre	33	25	2685	1846
		Post	39	30	1855	826
3a	43	Pre	41	25	2623	1466
		Post	96	7	1072	409
3b	14	Pre	39	26	2750	1747
		Post	93	16	1220	914
4a	46	Pre	96	9	2196	1069
		Post	30	21	2253	1074
4b	17	Pre	95	8	1049	476
		Post	38	28	2042	1058

Appendix E

Hand-in consent form

Appendix E

Consent Form
Experiment on Hypnotic Susceptibility and the Occluded Diamond Task
McGill University

Principle Investigator:
Alexandra Fischer
Department of Psychology, McGill University
Alexandra.fischer@mail.mcgill.ca
(514) 458-9389

Supervisor:
Dr. Amir Raz
Department of Psychiatry, Neurology and Neurosurgery, and Psychology, McGill University
Canada Research Chair in the Cognitive Neuroscience of Attention
McGill University and SMBD Jewish General Hospital
amir.raz@mcgill.ca
(514) 340-8222 ex. 7923

Introduction

You are being invited to voluntarily participate as a subject in a research study on hypnotic responsiveness and the Occluded Diamond Task, conducted at McGill University in the laboratory of Professor Amir Raz. You are eligible to participate in this research if you are 18 years of age or older and have no prior experience with hypnosis. This exclusion criterion does not include being in the audience of a stage hypnotist. It refers to any direct experience of being hypnotized.

You have the right to know about the purpose and procedures that are to be used in this research study, and to be informed about the potential benefits, risks, compensation and discomfort of this research. Before you give your consent to be a participant, it is important that you read the following information and ask as many questions as is necessary in order to understand what you will be asked to do, should you decide to participate. It is also important that you understand that you do not have to take part in this study.

Purpose of study

The purpose of this experiment is to study certain aspects of hypnotic susceptibility and their influence on performance on the Occluded Diamond Task.

Procedures

During the experiment you will be asked to perform the Occluded Diamond Task which is a short computer-based task on motion perception. Instructions will be provided and you will be asked to determine the direction of motion of various geometrical shapes.
You will also undergo a demonstration of hypnotic susceptibility, involving a simple hypnotic induction and a suggestion. The suggestion will not lead you to do anything against your will, nor will you at any point be put in a situation that is embarrassing or dangerous. You cannot be hypnotized against your will.
You will be thoroughly debriefed as soon as your participation is complete. At that time, all of your questions about the experiment and your individual responses will be answered.
Risks, Discomforts and Side Effects

Hypnosis involves no risks to subjects providing that certain elementary precautions are taken. In order to minimize risks, all hypnotic inductions will be administered by a trained professional (Dr. Raz is representative of and registered with the American Board of Psychological Hypnosis). All precautions will be taken to avoid the occurrence of unexpected adverse reactions and participants will be closely monitored. Because hypnosis sometimes involves extended periods of eye closure, subjects who wear contact lenses are encouraged to remove them before any session begins.

Benefits

This is solely a research project, and you will receive no psychological, medical, or other personal benefits from your participation. This is an experimental research study, and is not to be confused with psychotherapy, personal growth experience, or entertainment. There are no benefits to you personally, other than your compensation. However, information learned from this research may serve as an important vehicle for understanding the nature of hypnosis and automatic processing.

Voluntary Participation / Withdrawal

Your participation in this research is voluntary and you are free to withdraw your consent and discontinue participation at any time. If you participate in the study, you may refuse to answer any question(s) that might make you feel uncomfortable.

Confidentiality

All the information obtained about you during this research will be treated confidentially within the limits of the law. This information will be anonymized and kept under lock and key. No information that discloses your identity will be allowed to leave this institution. The results of this research may be published or communicated in other ways; however, your identity or any other identifying information will not be disclosed in any reports or publications.

Compensation

In return for your participation in this study you will receive extra credit toward course participation in the Department of Psychology.

Contact information or questions

If you have any questions about the research now or later, contact Alexandra Fischer at the email address noted above.

Signature:____ Date: ______________

Name of participant: ____

Consent form administered and explained in person by:

Signature:____ Date: ______________

Name of investigator: ____

Appendix F

Script of the hypnotic suggestion used in MoTraK

You have been very relaxed listening to my voice and I can see that you are really good at this sort of thing... Pretty soon I will count to three and you will open your eyes and look directly at the screen. Then, as you look straight at the screen and crisply see all the moving parts rhythmically dancing on it, you will also be able to imagine the occluders fixed in their place. These big, bright occluders will help you see the direction of motion of the moving parts. You will recognize the direction of motion instantly and without any effort as you have done before. You have already shown me and yourself that you know how to perform this task very well. That's why you will do just great. Ready now? I will count to three and you will let those occluders help you identify the direction of motion...