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Local Navon letter processing affects skilled behaviour: A golf-putting experiment

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Abstract

Expert or skilled behaviors (for example, face recognition or sporting performance) are typically performed automatically and with little conscious awareness. Previous studies, in various domains of performance, have shown that activities immediately prior to a task demanding a learnt skill can affect performance. In sport, describing the to-be-performed action is detrimental; whereas in face recognition, describing a face or reading local Navon letters is detrimental. Two golf-putting experiments are presented that compare the effects that these three tasks have on experienced and novice golfers. Experiment 1 found a Navon effect on golf performance for experienced players. Experiment 2 found, for experienced players only, that performance was impaired following the three tasks described above when compared to reading or global Navon tasks. It is suggested that the three tasks affect skilled performance by provoking a shift from automatic behavior to a more analytic style. By demonstrating similarities between effects in face recognition and sporting behavior, it is hoped to better understand concepts in both fields.

Introduction

Everyone is an expert, or at least skilled, at something. This may be a skill that a person has dedicated a great deal of time to (e.g., the ability to play a piano or golf) or it could be something that has been learnt incidentally during recreation (e.g., being able to identify a wine's vintage). Further, a skill can seem to develop almost automatically, such as the ability to recognise faces. One thing that links all of these skilled behaviors is their automaticity: individuals perform the behavior with little conscious control (Anderson, 1982). This paper looks at a variety of tasks that appear to have a carry-over effect resulting in a detriment in skilled performance immediately after the task.

According to Anderson's (1982) model of skill acquisition, novice performance depends on declarative knowledge that is held in working memory and requires extensive attentional resources. With continuous practice, declarative knowledge is translated into procedural knowledge, which contains productions representing information about how one does a task, such as how to swing a golf club (Beilock & Carr, 2004). Unlike declarative knowledge, the execution of a skill results from an automatic procedural control structure for which implicit knowledge runs from one production to the next without explicit conscious control (Beilock & Carr, 2004). In line with this model, Beilock, Wierenga and Carr (2002) found that experienced golfers performing under normal, practiced conditions could allocate a portion of their attention to other stimuli and task demands without impaired performance. Similar performance has been found in hockey players (Leavitt, 1979) and soccer players (Smith & Chamberlin, 1992). The cognitive mechanisms that underlie the execution of an expert or highly skilled task are governed by procedural knowledge that does not require constant attention, allowing attention to be directed elsewhere (Beilock,

Carr, MacMahon & Starkes, 2002). Moreover, the execution of a procedural skill occurring in the absence of conscious control results in less than optimal memories of the skill execution process. Thus, highly skilled performers' episodic memories of the step-by-step processes are impoverished, which results in the experience being difficult to articulate (Beilock et al., 2002).

DeCaro, Thomas, Albert and Beilock (2011) describe how interference with this highly learnt procedural expertise is responsible for the phenomenon known as choking: that is failing to perform as well under pressure as one does in practice. One explanation for some forms of choking is that there is explicit monitoring of one's behavior that only happens in high pressure situations (Beilock & Carr, 2001). This explicit monitoring is overly analytic and interferes with automatic expert performance.

In many ways, highly learnt sports performance is similar to other areas of expertise: for example, face recognition. Most people are very capable of recognising people that they know even under very poor conditions, yet this is something that happens without conscious control. People find it difficult to describe faces or the processes by which they recognise or distinguish faces (Bruce & Young, 1986). In these ways, therefore, sporting expertise has parallels with face recognition. These parallels are explored further here with support coming from a finding that a process which has a detrimental effect on face recognition skills (verbal overshadowing, Schooler & Engstler, 1990) also affects experienced players' performance when playing golf (Flegal & Anderson, 2008). It is also described how a parallel to the verbal overshadowing effect in face recognition has been generated using the reading of Navon letters. This leads to the two experiments that explore the effects that providing analytic descriptions and naming Navon letters have on golf performance.

Verbal overshadowing

Performance in face-recognition (arguably a skill that most people are experts at) is impaired following verbalisation tasks. Schooler & Engstler (1990) had people watch a video of a crime and then some of them spent time describing the face. These people were less likely to pick out the person in an identity parade than people who did not describe the face. The task of providing a description led to poorer face recognition. Fallshore and Schooler (1995) demonstrated that the effect only occurred for upright, same-race faces. Other-race and inverted faces did not show the detriment in performance after providing a description and so this confirmed that it is the highly learnt processing of typically experienced faces that is being affected by providing descriptions.

Further research has indicated that the effect could extend across perceptual modalities: Melcher & Schooler (1996) found that providing a verbal description of a wine impaired later recognition of that particular wine for experience wine drinkers. Such a detriment was not found for either non-wine drinkers or wine experts. This clearly indicates that the level of a skill is important. The difference between experienced and novice wine drinkers can be explained as former would have developed sufficient skill in wine recognition such that their perceptual skill would exceed their verbal skill in describing wines. This contrast in perceptual and verbal skills leads to the impaired performance caused by verbal overshadowing in the same way that a person is impaired in face recognition. A wine expert would approach the task of wine recognition in a more analytic manner with an established wine related vocabulary and so describing the wine does not

lead to a deficit in recognition. In general, people do not have an effective vocabulary for describing faces (in terms of how they differ from each other) and so wine expertise does not relate to the skills that people generally have with faces.

This detriment in performance following a description was labelled the verbal overshadowing effect because it was assumed that it occurred due to the perceptual memory being overshadowed by the abstract verbal description provided (Schooler, 2002). Thus, interference between the verbal memory and access to the original memory impaired performance (Schooler, 2002). However, further research on the effects of verbalisation found that the verbal overshadowing effect extends beyond the particular stimulus that is verbalised (Dodson, Johnson, & Schooler, 1997). Brown and Lloyd-Jones (2003) showed that it was not the description of the face that was important; providing any verbal description, even one of a car, led to the poorer face-recognition performance. These findings cannot be explained by a disruption in the perceptual memory caused by verbalisation. As a result, an alternative explanation was provided, based on the idea of a transfer-inappropriate processing shift (Schooler, Fiore, & Brandimonte, 1997) in which there is a shift from automatic-style processing to controlled processing, the latter of which is less effective for face recognition.

This verbal overshadowing effect has an analogue in the domain of procedural memory. Flegal and Anderson (2008) investigated whether describing the execution of a golf skill disrupts later performance. Golfers of low and intermediate skill were required to perform a putting task in which they had to achieve a criterion of three consecutive putts. Half of the participants were required to spend 5 minutes writing a description of everything they do while putting. For skilled golfers, providing a description of their putting experience resulted in them requiring twice as many putts to achieve the criterion of three

consecutive sinks than in the control condition. However, for lower skilled golfers providing a description had no effect on their performance. This indicates that consciously reflecting on a skill before it is carried out can impair motor performance if individuals possess a high degree of procedural knowledge.

The Navon effect

Macrae and H. Lewis (2002) hypothesised that other tasks would lead to carry overs that would produce impairments in face recognition. They suggested that tasks that promote the featural or local processing of faces would impair recognition performance. To test their hypotheses, Macrae and H. Lewis (2002) developed a methodology to prompt the use of either a local or global processing orientation, using a Navon-letter-identification task. This task involves the presentation of Navon letters (Navon, 1977) between the encoding and the recognition phase of a face-recognition task. Navon letters are large letters made of a repeated smaller letter of a different kind (See Figure 1). Identifying the large letter requires a global processing style, whereas identifying the small letter requires a local processing style. Thus, identifying the different letters initiate processing strategies that differ in the extent to which they support successful face recognition (Macrae & H. Lewis, 2002). Using an eye-witness line-up style experiment, Macrae and H. Lewis (2002) found that identifying the local letters of Navon stimuli resulted in poorer subsequent face recognition compared to a control task or the Global-letter task. This clearly demonstrated that the local-Navon task interfered with the face recognition task that immediately followed it.

Perfect, Dennis and Snell (2007) replicated Macrae and H. Lewis's (2002) study on

line-up recognition, but instead one group first did the global Navon letter task followed by the local letter task, whilst another group processed the local Navon letter task followed by the global Navon letter task. Results were similar to those obtained by Macrae and H. Lewis (2002): the global-local processing condition resulted in poorer subsequent face recognition, whereas the local-global processing condition improved face recognition. This demonstrated that it was the task that was done immediately prior to the face-recognition task that was influencing performance. A further study by Hills and Lewis (2007) found that the local-Navon task detriment on face recognition was quite short lived and disappeared after viewing five faces.

Given the pattern of findings, there is good reason to believe that the Navon effect is underpinned by the same mechanism as the verbal overshadowing effect. To test this, Lewis, Seeley, and Miles (2009) investigated the effect of Navon effect on the recognition of wines in a manner similar to the verbal overshadowing effect experiment on wine recognition (Melcher & Schooler, 1996). In line with their prediction, global Navon processing led to better performance in a subsequent wine recognition task than local Navon processing. This indicates that visual processing influences perception across modalities and supports the idea that the verbal overshadowing effect and Navon effect share similar underlying mechanisms.

Further analysis of the Navon effect revealed that specific properties of the Navon letters are important to produce the Navon effect. Normally the global letter of the Navon stimulus is more obvious than the local letter, which results in the Navon stimulus having global precedence. Perfect, Weston, Dennis and Snell (2008) replicated the methodology of previous studies using the Navon stimuli, but manipulated the precedence of the letter stimuli such that they had either global or local precedence. It was found that face

recognition was impaired in the conditions in which participants had to ignore the letter with precedence. Put simply, the Navon effect on recognition performance can be reversed if the Navon stimuli have local precedence. Perfect et al. (2008) proposed that responding to the non-dominant aspect of the Navon stimuli requires a transfer from automatic to controlled processing, whereas responding to the dominant aspect of the Navon stimuli requires no such shift, favoring automatic processing (Perfect et al., 2008). It is this transfer to controlled processing that carries over into the face recognition task and leads to the detriment in performance in a task that is normally carried out as an automatic process.

Automatic vs Controlled behaviours

While the parallels between verbal overshadowing effect and the Navon effect are interesting, they also relate to a much broader field of psychological debate. Dual-process theories (see for example: Evans & Stanovich, 2013; Shiffrin & Schneider, 1997) describe how the same process can be performed in either an automatic manner or a controlled manner. It is proposed here that golf playing by skilled people and face recognition are both typically performed using automatic processing. The verbal-overshadowing and the local-Navon task each interfere with this automatic processing leading to the more controlled processing and hence poorer performance. Exactly why these tasks interfere with automatic processing remains unclear but it is likely that it has something to do with suppression (Lewis, 2006; Perfect et al., 2008).

Both tasks involve suppression of obvious features of the stimuli in search of more descriptive features: The local-Navon task requires suppression of the immediately presented response in order to respond to the smaller letters; whereas the process of giving a description lasts five minutes in which the participant may start with the obvious features

but eventually needs to suppress these to describe the less obvious features. If this is the case then the verbal overshadowing and local Navon processing should have similar effects on skilled performance. Two experiments are presented that explore this further.

Experiment 1

According to Perfect et al. (2008), the Navon effect should occur for any task that is processed in an automatic manner, but can also be encoded in a controlled and analytic style if necessary. The present study investigated whether performing the Navon letter-identification task would affect golf performance. For skilled golfers who possess a high degree of procedural knowledge, the execution of the golf swing is an automatically controlled motor skill. If identifying the local letters of a typical Navon stimulus requires controlled responding, then performing this task may disrupt later skilled performance, due to a shift from automatic to controlled processing. Thus, it is hypothesised that global Navon processing will lead to better subsequent golf performance than local Navon processing. This hypothesis was explored in Experiment 1. Further, the current study aimed to compare any Navon effect against the verbal overshadowing effect observed by Flegal and Anderson's (2008). As such, a partial replication of their study was also included.

Felgal and Anderson's (2008) study employed a between-participant design. In such a design it is necessary to match the skill levels of participants in different groups. The current experiment employs a within-participant design with counterbalanced orders. This kind of design has been used previously in the Navon-effect literature (e.g., Lewis, Seeley & Miles, 2009) in order to reduce the variance introduced between participants. This method is justified because the Navon effect has been found to be short lived (Hills & Lewis, 2007)

and if a participant does two consecutive tasks then only the last task before test is found to have an performance (Perfect, 2003). As each participant only does each task once during the whole experiment (except for the putting task) there is no opportunity for repetition to lead to attenuation of the effects.

Method

Participants

Twenty right-handed participants were recruited via an opportunity sample. Participants were aged between 20-68 years old with a mean age of 25 years. The inclusion criterion for participation was that participants had to play golf on a regular amateur basis and either be a member of a golf club or the university golf society. All participants owned their own clubs. Golfing handicap was not used as a measure of skill because the task employed here only assessed putting skill rather than all aspects of a round of golf.

Materials

A set of Navon letters generated by Brand (2005) was used. The stimuli consist of large letters made from different repeated smaller letters (See Figure 1). The Navon letters were black and presented on a white background with a height of 100mm and a width of 50mm. They were presented as a series of images on a laptop computer.

A 2.70m by 1.0m indoor high quality synthetic green was used for the putting task. Participants putted up a gradual incline to a putting cup that was 0.5cm smaller than regulation size and located 2.1m from the starting mark. A right-handed putter was available for participants together with a collection of standard golf balls.

Procedure

The experiment began with five practice putts. Following this, participants carried out one of the four tasks prior to immediately being tested on their putting skills. Which task the participant did was counterbalanced but all participants did all tasks and each task was followed by a putting test. The four tasks were as follows: a global Navon task in which participants read aloud the large letters as they appeared on a screen; a local Navon task in which participants read aloud the small letters of the same stimuli; a description task in which they wrote a detailed description of how they performed a putting task, and a control task in which participants read a newspaper article to themselves that was unrelated to golf. After completing the relevant task for 5 minutes, participants did the golf-putting task until they reached the criterion of three consecutive on-target putts. This procedure was repeated for the four task conditions with a short break between each.

Design

A within-subjects design was used and the independent measure was the nature of the task (global, local, description or control) prior to the golf-putting task. The order of these tasks was counterbalanced across participants. The dependent variable was the number of putts required to achieve the criterion of three consecutive on-target putts.

Results

Figure 2 shows the pattern of putts required to reach criterion in each condition. The median number of putts required to achieve the criterion of three consecutive putts was higher after participants were required to identify the small letters of the Navon letter when

compared to the other three task conditions. It can also be seen from Figure 2 that the data obtained from the four task conditions are heavily skewed as would be expected given this type of measure.

As the data are non-parametric, a Wilcoxon Signed Ranks test was used. This showed that a significantly greater number of putts were required to achieve the criterion in the local condition compared to the global condition, ($z = 2.437, p = .015$). This was significant even after a Bonferroni correction had been applied. It also showed there that was no significant difference in the number of putts required in the control and description condition, ($z = 1.222, p = .22$), but there was a significant difference in the local and description condition ($z = 2.691, p = .007$). This too was significant after a Bonferroni correction.

Discussion

The present study aimed to investigate the effects of Navon processing and verbalisation on golf performance. The results showed that responding in the local Navon letter identification task impaired experienced golfers' performance on a subsequent golf-putting test compared to global responding. This finding supports the suggestion that local Navon processing impairs the execution of a procedural skill. Also, it demonstrates the link between golfing performance and other tasks that have been shown to be affected by Navon processing (i.e., face recognition and wine tasting).

The results from the verbal description condition did not go in the direction predicted. It was predicted, based on the findings of Flegal and Anderson (2008), that providing a description would interfere with performance. No such interference was found.

There are several differences between the study presented here and Flegal and Anderson's that may have been responsible for the difference. Most importantly, the researcher did not encourage the participant to continue to write for the full five minutes available to them. As a result, some participants wrote for only a minute and then had four minutes of quiet before the putting exercise. The Flegal and Anderson study does not say how many participants wrote for the full five minutes but, given that their study produced written reports of about 140 words, it is likely that more of the five minutes was used in that study than in the current study. Brown and Lloyd-Jones (2008) have demonstrated the importance of the length and time course of the verbalisation in creating the verbal overshadowing effect and so it is likely that this could have accounted for the failure to find the effect in the current experiment.

Experiment 2

The second experiment built upon the first experiment in several ways. The first way was that participants were encouraged to verbalise orally for the full 5 minutes. This was designed to produce a procedure that was more similar to the types of procedures that robustly produce verbal overshadowing in face recognition. A second difference was the inclusion of non-golfers in the experiment. If the processes that are being explored are affecting skilled performance then one would not expect to see any effects on novices. Indeed, this is what Flegal and Anderson (2008) found in their verbal overshadowing experiment.

The putting task was also changed for the second experiment. In each condition the participant had five putts and had to get a ball to stop as close to a marker as possible.

Average distance to the marker when the balls stopped was used as the dependent variable. While this does not match golf putting exactly, there would be sufficient overlap in order to assess performance. There are several advantages for this method. First, it provides a parametric variable of averaged distance to the marker, which allows for clearer analysis. This change also allowed for the use of Bayesian analysis of the key hypotheses using the method designed by Rouder, Morey, Speckman and Province (2012). In addition to the standard null-hypothesis significance testing, the results below also report the Bayes factor which is odds ratio of the null hypothesis to the hypothesis. A Bayes factor value of one third would mean that the hypothesis is 3 times more likely than the null hypothesis given the data and the priors, and has been suggested as a cut off when deciding that data 'substantially' favor the hypothesis (see Rouder, Speckman, Sun, Morey & Iverson, 2009, for more details). The second advantage of this style of putting task is that the entire assessment occurs with 5 putts of the task of interest. In Experiment 1, participants were often using over 10 putts to reach criterion. It is known from face recognition tasks that the Navon effect can be short lived (Hills and Lewis, 2007; Weston & Perfect, 2005) and so after the first 10 putts it is not likely that the task of interest is having any further effect on performance.

One further addition to the procedure was the inclusion of a fifth condition. Verbal overshadowing is produced when a person describes a face immediately before doing a face recognition task. Brown and Lloyd-Jones (2003) have shown that it could be any face or, indeed, a car. It is the processes involved in the task rather than the relationship to the to-be-done test that is important in producing a verbal overshadowing effect. Consequently, in the current experiment, it was explored whether describing a face also leads to a detriment in golf performance for experienced players. A fifth condition where the participant had to

describe a face for five minutes before putting golf balls was, therefore, included in the experiment.

Method

Participants

Sixteen regular amateur golfers were selected via an opportunity sample. These participants were aged between 20-32 years old with a mean age of 26 years. They were recruited from a golf club and reported playing golf at least once a month for at least three years. A further 16 psychology undergraduates were recruited as novice golfers. These participants had no experience of playing golf and received course credit for taking part. They were aged between 20 and 23 years with a mean age of 21 years. All participants were right-handed.

Stimuli and apparatus

Golf performance was measured on an artificial putting green which was 2.0m by 1.0m. A standard putter and 5 golf balls were provided. A target marked by a small cross was placed 1.5 metres from a line where 5 balls were placed which the participant had to putt.

The set of Navon letters used in Experiment 1 was used here. A high definition portrait of an unfamiliar male face was also used for one condition and this was presented in color with a height of 100mm on a laptop.

Procedure

Performance was measured for a series of putts over a distance of 1.5 metres and was assessed by the distance between where the ball stopped and the target cross. The session began with five practice putts. This was followed by the five different conditions performed in different orders for each participant. In each condition the participant did a task for 5 minutes. This would be to either read a series of Navon letters either as local or global format, to describe the process of taking a putt being encouraged to speak for the full 5 minutes (if the participant stopped verbalising then they were asked 'tell me more about the standing position' or 'tell me more about the grip'), to describe from memory a face that was presented to them for 30s, or to read from a newspaper. Immediately after this task, the participant attempted to putt five balls such that they stopped close to a target cross. Each attempt was measured and the ball was removed before the next attempt. If the ball fell off the putting mat or was more than 45cm from the target then a value of 45cm was recorded as the distance. Following the five putts the participant moved onto the next condition until he or she had completed all five conditions.

Design

A mixed-model design was used. The within-subject independent variable was the nature of the task (global Navon, local Navon, putt description, face description or control) prior to the golf-putting task. The between-subject factor was whether the participant was a regular golf player or a novice. The dependent variable was the average distance between the ball and the target over the five putts in each condition. The order of the conditions was counterbalanced across participants.

Results

The average performance in the putting task for participants in each condition is shown in Figure 3. A mixed-model ANOVA was performed with the between-subject factor of experience (golf player versus novice) and the within-subject factor of condition (Local Navon, Global Navon, Putting Description, Face Description, Control). This analysis found that regular golf players were significantly better than novice players ($F(1,30) = 16.598$; $p < 0.05$). The main effect of condition was not significant ($F(4,120) = 1.160$; $p > 0.05$) but the interaction was significant ($F(4,130) = 2.516$; $p < 0.05$).

Simple main effect analyses were conducted on the data for the golf players and the novices separately. For the novices, there was no significant effect of condition ($F(4,60) = 0.106$; $p > 0.05$). For the golf players, there was a significant effect of condition ($F(4,60) = 5.273$; $p < 0.01$). Planned-pairwise comparisons (with Bonferroni corrections) found the following significant differences: performance after the global Navon tasks was better than after the local Navon task ($p < 0.05$, JZS Bayes factor = 0.083); performance after the description of putting task was worse than after the control task ($p < 0.05$, JZS Bayes factor = 0.192), and performance after the description of the face task was worse than after the control task ($p < 0.05$, JZS Bayes factor = 0.141). The Bayes analyses confirm that these significant differences provide substantial evidence for the three hypotheses.

Discussion

Experiment 2 revealed that there were three tasks that had a detrimental effect on experienced golf players' performance. The first was the processing of local Navon letters.

This is a replication of the findings of Experiment 1 using a task that produced parametric data. The second was providing a verbal account of how to putt a golf ball. This is a replication of Flegal and Anderson (2008). The third was the process of describing a face. This is a new finding but one that was predicted based on the effects of verbal overshadowing as described by Schooler and Engstler-Schooler (1990) and Brown and Lloyd-Jones (2003). It should be noted that these processes did not have a large effect on the novice golf players; this is to be expected as it was predicted that the tasks would affect highly learnt behaviors because they tend to be executed automatically and without conscious awareness.

General Discussion

The findings of the current study take the effect of processing Navon letters on perceptual experiences (Lewis et al., 2009; Macrae & H. Lewis, 2002) into the domain of sports performance. Previously, a Navon effect found for the recognition of wines and faces but here we show that an analogous effect is found in golfing performance. The Navon effects in face recognition have been explained by Perfect and colleagues (2008) in terms of a controlled processing account. Similarly, this account could also explain the current findings. The execution of a motor skill for experienced performers results from an automatic procedural control structure (Anderson, 1982). The processing of local letters in typical Navon stimuli requires controlled and analytical responding, as does the description of putting or of a face. This controlled and analytical behavior carries over to any task that is performed immediately afterwards (Lewis, Mills, Hills & Weston, 2009). Therefore, when golfers are required to perform one of these analytic tasks before carrying out a golf-putting

task, a transfer from automatic to controlled processing results in impaired performance, due to a processing strategy that is suboptimal for the execution of a procedural skill.

Further support for this shift from automatic to controlled processing can be found in that the same detriment in performance is not found in golf novices. Golf novices would not typically employ automatic behaviors when putting a golf ball and so there are no automatic processes for the local Navon task or the description tasks to interfere with.

The current findings concerning providing a verbal description of putting are consistent with the findings obtained by Flegal and Anderson (2008). Given that the size of this detriment is similar to the size for the detriment following local Navon letter then it is possible that similar processes are involved. Beilock and colleagues (2002) found that when experienced golfers were required to attend to a specific component of their golf swing, it disrupted golf putting performance. This indicates that skilled motor performance is impaired by explicitly attending to the automated or procedural skill processes during execution (Beilock et al., 2002). This would suggest that overthinking, which involves controlled processing, impairs motor performance due to task interference rather than having any effect on long-term retention. Again, this performance detriment is only present for skilled golfers and not for novices implying that it is indeed an element of expertise that is affected following a verbal description of putting.

At this point it is worth pointing out that the experienced golf players in this study, and also in Flegal and Anderson's (2008) study, were amateurs at the sport. It remains an open question whether professional golfers would be affected in similar ways as the regularly playing golfers recruited for these studies. If one considers the experts to be using procedural systems that are even more automatic than in the experienced golfers then one would predict that they too would show the detrimental impact of analytic tasks. However,

the wine tasting study by Melcher and Schooler (1996) found that wine experts, unlike intermediately skilled people, were unaffected by verbal overshadowing. For wine experts, the task of tasting wine had become analytic. Professional golfers' performance might similarly be analytic rather than automatic and so it is possible that the deficits found here would not generalise to people with higher levels of expertise than those in our participant group. Further research with professional sportspeople would be required to explore this.

Golf putting is a relatively discrete task that has a clearly defined beginning and ending point and easily lends itself to this type of research. It would be anticipated that the interference observed in Experiments 1 and 2 here would also occur in other domains of sporting performance. A disruption in performance due to the allocation of attention to the online step-by-step execution of a well-learned skill has been found for ice hockey (Leavitt, 1979) and soccer dribbling (Smith, & Chamberlin, 1992; Beilock et al., 2002), thus it would be anticipated that the Navon effect would also extend to these sport-related tasks. Also, there are potential applications in other areas of highly learnt skills such as musical performance.

In conclusion, the current study has extended previous research on the effect of processing Navon letters in perceptual modalities (Macrae & H. Lewis, 2002; Lewis et al., 2009) to the execution of a procedural skill. It was found that performing the local Navon identification task impaired experienced golfers performance on a subsequent golf-putting task. This result provides support for Perfect and colleagues' (2008) controlled processing account of the mechanisms underlying the Navon effect, which can also account for a Navon effect for perceptual experiences (Lewis et al., 2009). This research also draws parallels with the verbal description impairment in performance illustrated by Flegal and Anderson (2008) and demonstrates that it is not necessarily just over analysis of the task to be performed

that causes interference with skilled performance but any kind of analytic behavior can have similar effects. Ultimately, this research may lead to strategies to reducing choking in the sporting domain, but may also be able to improve other skilled behaviors in high pressure situations such as face recognition in a forensic line up.

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Figure 1. Example a Navon letter. A upper case 'B' is formed from repeated upper case 'D's.

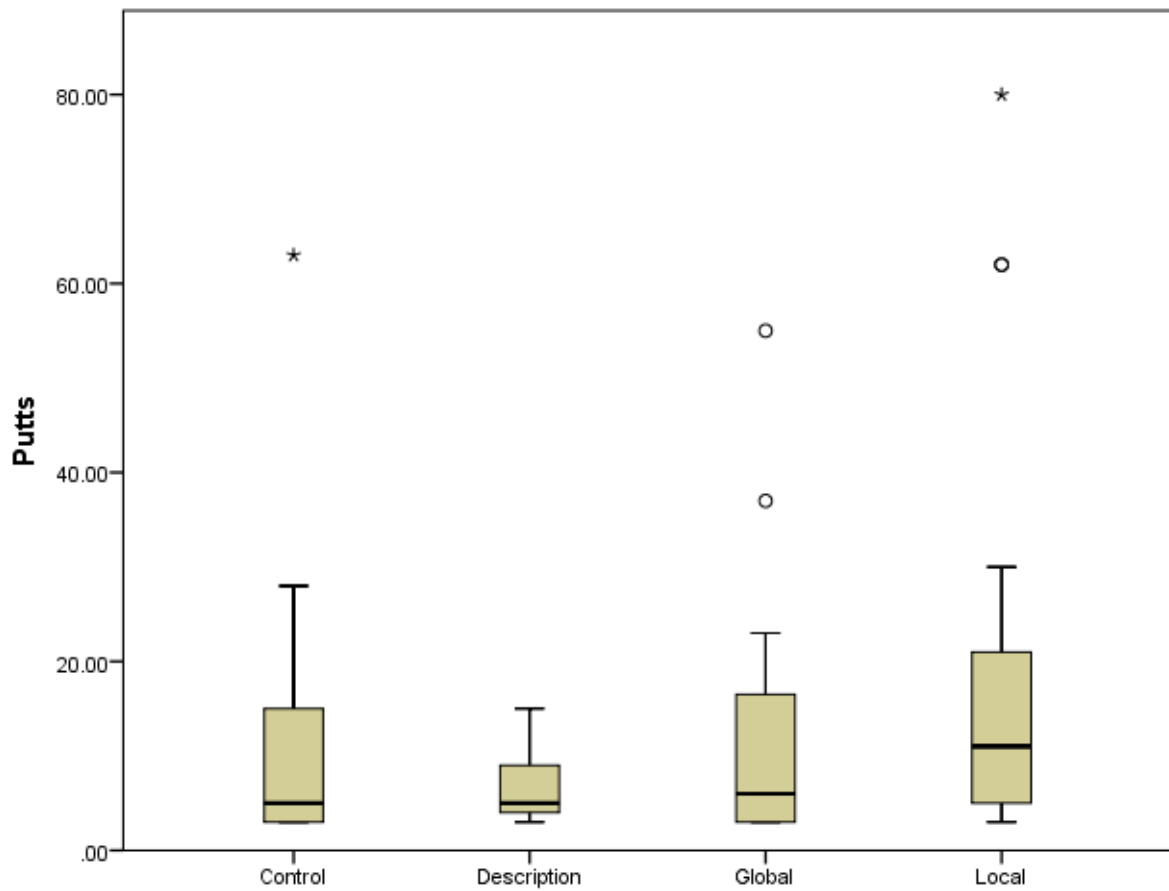


Figure 2. The results of Experiment 1. The medians and interquartile ranges for the number of putts required to reach the criterion of three on-target putts in a row. The median performance in the Local Navon condition is worse than in the other three conditions.

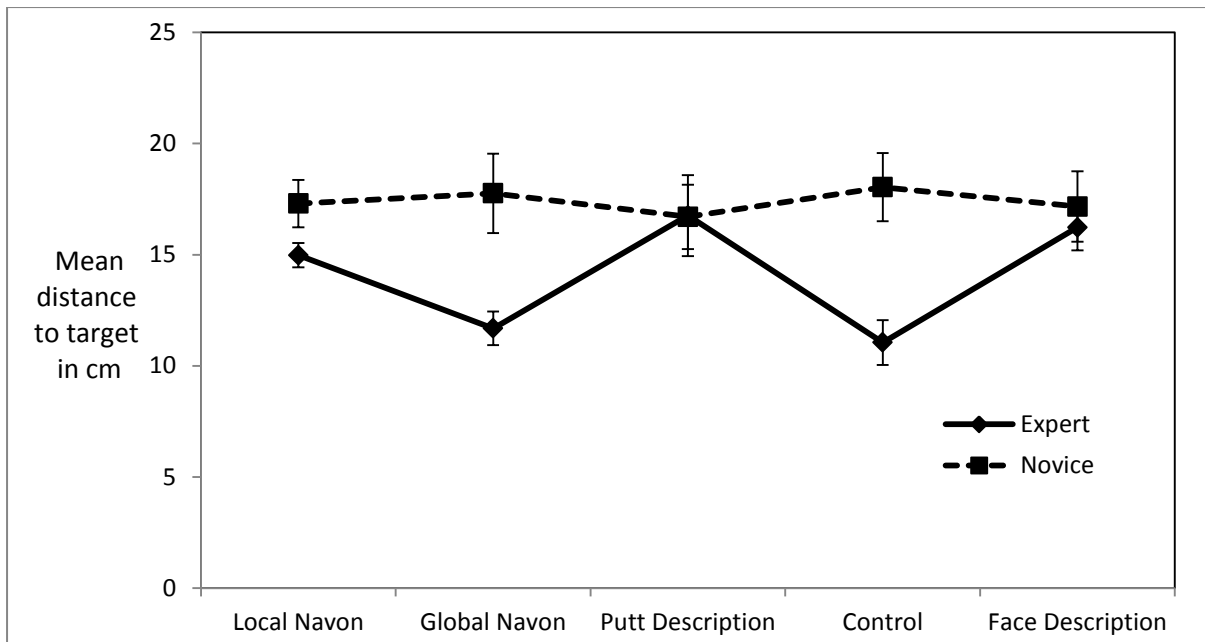


Figure 3. Results from Experiment 2 showing the average distance to the target for the expert and novice golf players split according to the task they did prior to the putting task.