Choosing one goal at the expense of another and the optimal behaviour in decision making

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Abstract

In this experiment, we asked participants to decide whether to divide their mental resources between two equally likely potential goals or to prioritise one of them at the expense of the other. Faced with this decision, when the task is simple, the optimal strategy is to prepare for both of them. As difficulty increases beyond the point where participants could perform both tasks accurately, the optimal strategy should consist of participants focusing on one goal at the expense of the other. Previous research conducted by Clarke and Hunt (2015) has shown that people do not choose an optimal strategy but rather attempt to allocate resources towards both goals. In an attempt to help participants overcome uncertainty, one group was given a training trial, based on the same principles as the main experiment. Participants have previously shown the ability to perform optimally in the training trial (Clarke and Hunt, 2015). Whilst they performed this task accurately, it did not have an impact on their performance in the second session. By asking participants to take part in the training trials, the aim was to highlight the optimal strategy and encourage them to use the same strategy in the main experiment. Across two sessions of 48 trials, most participants changed their strategy at a near optimal point during the second session, leading to the conclusion that, whilst the training trial might not have influenced their performance, a learning effect caused by the two sessions at a week apart could explain the positive change in strategy. The findings of this study have great implications in the understanding of optimal behaviour of humans when choosing one goal at the expense of the other, offering a learning effect as a possibility of understanding individual mental resources and skills.

Keywords: decision making, optimal behaviour, risk

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The ability of humans to make decisions is a combination of multiple different processes controlled by one's unconscious states (Lee et al, 2012). Visual search, performed by most mammals is essential to one's survival. Whist finding oneself in a highly complex environment, adopting effective strategies in gathering relevant information from a multitude of stimuli provides high functioning and aids the aforementioned survival. The ability to encode relevant information from one's visual field aids the process through which humans make decisions by offering relevant information about the perceived target. (Deubel & Schneider, 1996).

The decision making behaviour is a human cognitive process that involves the selection of a logical choice from a wide set of alternatives resulting in a final choice that may or may not prompt action (Cohen et al, 2007; Wang & Ruhe, 2007)). Choice can be described as the outcome of the process of evaluating different options, assessing and judging those options and reaching a decision about what option to choose. In order for this process to be undertaken, the presence of two or more alternatives with some positive value is crucial (Hastie, 2001).

In order to understand how the decision making process takes place, the different underlying factors have to be taken into account. Most of the important decisions humans have to make throughout their life involve risk and uncertainty. Within scholarly research, a clear line has been drawn between risk and uncertainty (Knight, 1921). Decisions involving an aspect of risk are those where likelihoods of the several possible outcomes are objective or known (much like flipping a coin) whilst uncertainty occurs in situations where the person in the deciding position has to estimate those likelihoods of several possible unknown outcomes (i.e the chances of sunny weather next week). However, the general understanding of decision making involving uncertainty is much less advanced than the knowledge of behaviours involving risky decision making. Nonetheless, it has been argued that models used to understand risky decision making could possibly be extended to processes involving uncertainty (Wu, Delgado & Maloney, 2009).

Empirical research on how people make decisions and choices covers a wide range of different situations in which humans would have to exert such behaviour. Such research suggests that humans faced with different situations frequently think about decisions in a similar way, highlighting that humans share common sets of cognitive skills (Hastie, 2001). Such cognitive skills, along with their limitations, are significant in coercing decisions, emphasizing that decision making fluctuates from what may be perceived as ideal, logical and optimal behaviour in real life situations. Ideally, humans should choose an option that would have the best outcome for the situation, therefore displaying an optimal behaviour. However, in reality humans do not always reach decisions based on optimal strategy due to possible personal limitations (Wolpert & Landy, 2012; Morvan & Maloney, 2012; Clarke & Hunt, 2015)

In their recent study, Clarke and Hunt (2015) defined optimal decision making behaviours as behaviours that reach the best attainable outcome while reducing risk and energy usage to a minimum. Whilst the literature of optimal decision making behaviours in humans is well documented (e.g, Kibbe & Kowler, 2011; Najemnik & Geisler, 2005; Oruc, Maloney & Landy, 2003; Wolpert & Landy, 2012) and supports the premise that motor control makes the most of action consequences given specific limitations of task, motor and sensory uncertainty (Wolpert & Landy, 2012), other studies have successfully demonstrated that the predictable achievement in more premeditated choices is tainted by the human failure to maximise it (Morvan & Maloney, 2012; Zhang, Morvan & Maloney, 2012; Clarke & Hunt, 2015).

Most recent visual search literature provides intriguing insight into the human failure to exploit the likely achievements in more conscious choices, focusing on one highly influential model introduced by Najmenik and Geisler (2005). Their proposed model suggests that eye movements are solely directed towards the location that decreases target uncertainty by the maximum amount possible (Najemnik & Geisler, 2005). However, Morvan and Maloney (2012) offer further evidence that human, in their visual search, do not always focus on locations that capitalize on the probability of detecting a target in a reliable manner. Their studies suggest that visual target fixations are biased and are mainly based on human tendencies towards a certain direction rather than visual sensitivity and uncertainty, highlighting further flaws in the human visual search process and therefore in the decision making behaviours (Morrvan & Maloney, 2012). According to these findings, it is crucial to note that there is conflicting evidence regarding the optimality of human visual search and that in some, if not most cases, humans do not choose the strategy expected if they were optimal decision makers.

In an attempt to further the strength of these arguments, Clarke and Hunt (2015) researched the human failure to adopt an optimal behaviour strategy when having to choose between two goals. They thoroughly analysed this using four different experiments investigating whether participants would exhibit more strategically reliable decision making behaviours in tasks that involve deliberate decisions with more tangible outcomes (Clarke & Hunt, 2015). The experiment consisted of four different tasks, two of which focused on physical abilities. The throwing task aimed to create a point at which it would be necessary to change between dividing available resources across two goals and investing all of them in one target at the expense of the other, in order to achieve the best possible outcome. Eight hoops were placed on the ground, four in each direction (north and south) with the blue hoop furthest from the centre and the red one closest. Participants were asked to choose a standing position from which to throw a bean bag in its corresponding hoop, without knowing the direction of the throw until after they made the decision regarding their standing position. The optimal strategy would have been to adapt one's behaviour to the increasing distance of hoops. The reaching (table task) experiment consisted of beanbags placed on a table whilst the participant had to decide between three chairs in order to be able to reach a certain colour. This helped demonstrate that participants were able to understand the instructions given as well as the constraints and own limitations present and were able to behave accordingly to the difficulty of the task. Clarke and Hunt (2015) observed a remarkable failure to make optimal decisions in all their experiments, except the reaching task.

Their findings raise the question of why humans are seemingly unable to exhibit the same optimal behaviour present in the reaching task in other similar situations, such as the throwing task. They identified three possible problems: failure to accurately estimate own performance, failure to frame decisions correctly and the possibility of prioritising something other than accuracy (Clarke & Hunt, 2015).

Within the first possible problem, the Dunning-Kruger effect (Dunning & Kruger, 1999) is taken into account. This effect is a cognitive bias describing the illusory superiority of relatively unskilled people when assessing their own ability, attributed to the failure of the unskilled person to acknowledge their own lack of ability. The optimal strategy present in the reaching task can be attributed to the estimation of the participant's own arms which is, according to them, less abstract and relatively easy to estimate. However, participants were subject to extensive practice trials in the throwing experiment, leading to the conclusion that the inability to estimate own performance is greatly implausible (Clarke & Hunt, 2015).

A key finding from decision making research represents the ability of humans to form a mental picture of the decision problem they are facing (Levin, 1987; Morvan & Maloney, 2012).

The framing model of a decision includes both the information about the decision problem and the context of it. The choices made about the same decision will vary across each person because of individual differences in the way information is perceived and interpreted (Kahnemann & Tversky, 1984). When faced with the choice of investing in one or both options, achieving an optimal behavioural strategy requires participants to make a logical decision (Clarke & Hunt, 2015) and the reaching task showed that participants were highly effective in making such choices. However, it could be possible that the additional performance demands introduced in the throwing task (accurately hitting the corresponding hoop not just aiming at it) distracted the participants from framing the decision effectively (Clarke & Hunt, 2015). Therefore, given the many ways in which humans can exhibit suboptimal behaviours, the question of why participants could not reach an optimal strategy throughout all experiments remains unanswered.

Given the outcomes of this group of studies, introducing the reaching task as part of the throwing experiment could lead to the expectation that participants would achieve an optimal behavioural strategy through a learning effect. The following study is a replication and extension of the throwing experiment conducted by Clarke & Hunt (2015). We introduced the reaching task as a learning opportunity before the second session and hypothesised that participants who are subject to this training would achieve optimal or near-optimal strategy in the second session compared to the group of participants who do not undertake that part of the study whilst the results of the first session are expected to be similar for both groups.

Method

Design

The conducted study was a 2 × 2 × 2 mixed factorial design experiment with one dependent variable (movement of participants) and three independent variables with two levels each (the group: Sudoku and table task; session: session one and two and distance: near and far). The group allocation was randomised and each participant was tested individually. The first and second session of the study was the same for every participant, however, one group was given a training task at the beginning of the second session and the other group was given a five minute puzzle. The direction of throwing in each trial was randomised using excel and the colour of the bean bag was randomly selected from a black bag before each trial.

Participants

Twenty undergraduate students at the University of Aberdeen were recruited to participate, 10 for each condition (eleven females and nine males with a mean age of 22.8) All participants were recruited via word of mouth after acknowledging they have not participated in the similar study conducted last year and were therefore unaware of the aims of the experiment. They provided written consent to take part in the study and were thoroughly debriefed and encouraged to ask questions at the end of the second session. The experiment was reviewed and approved by the School of Psychology ethics committee.

Materials and procedure

The experiment was a replication and extension of the similar study conducted at the university the previous year. The main task involved throwing a bean bag into one of two hoops located either North or South from the centre point (marked as 0), with the participant being unaware of which hoop would be designated as the target at the moment of choosing a place to stand. For two hoops close to one another, the ideal position would be in the middle whilst for hoops at a distance too big for the participant to throw accurately from a halfway location, the ideal behaviour would be for the participant to stand closer to one hoop, aiming towards an overall success rate of 50%.

The experiment took place on University campus, in a sheltered area with concrete slabs on the ground (see Fig. 1). The measurement of each slab was 0.46 x 0.61 m and provided useful markers for the position of each hoop and recording the standing position of participants. Two sessions were held at a week apart and at the beginning of each, 48 practice trials were offered to measure the accuracy of the participants. During these trials, participants were asked to stand in the middle (marked as 0) and throw bean bags corresponding to each hoop 12 times in each direction and the bean bags were cleared from the area after each toss. Coloured hoops were positioned north and south from the centre, on slabs 3 (red), 7(green), 11(yellow) and 15(blue) for South and on slabs -5(red), -9(green), -13(yellow), -19(blue) for North. A trial was recorded as accurate if the final resting place of the bean bag was inside the corresponding hoop or touching it. The performance was recorded to allow for a better understanding of participant throwing ability. These trials were then followed by a short break whilst the hoops were rearranged.

FIGURE 1.

Throwing task setting. Hoops were placed in previously marked slabs. After the accuracy trials, hoops were moved for the main experiment.

Session 1: During the main experiment, hoops were always positioned north and south from the centre on slabs 5(red), 9(green), 13(tallow) and 17(blue). The hoops were taped down onto the eight different slabs, four in each direction relative to the unmarked centre point: slab 5 (red hoops) and 17 (blue hoops). Participants were given the following instruction:

‘’You will be given a bean bag. Your task is to get the bean bag into one of the two hoops of the same colour. For example, if you are handed a yellow bean bag, you will have to get the bean bag into one of the two yellow hoops. I am not going to tell you which hoop yet, first you need to select a place to stand. You can choose anywhere you like within the paved area but remember, your task is to get the beanbag in the hoop of specific colour. Once you are in position, you will be given the direction of the hoop you need to aim at.’’

Participants received one practice trial and then completed forty-eight decisions and throws in each block (16 trials for each hoop colour in a random order) The main experimenter stood on the grass, recording the accuracy of the throw (marked as 1 or 0), the colour of the bean bag (R, G, Y, B) and the position of the participant (the numbers 0 to 40 had been chalked on the edge of the paved area from one end to the other to enable quick and subtle recording of the standing position). The order of colours and direction of throw was randomised separately for each participant.

After the completion of Session 1 (accuracy measurement and throwing task), the participant was requested to return for Session 2 one week later.

Session 2: Before the accuracy measurement, the participants were randomly selected for the reaching task vs. Sudoku task, with 10 participants in each condition. The reaching task was a replication of the reaching experiment conducted previously (Clarke and Hunt, 2015) and involved six bean bags placed on a long table with the two red bean bags placed near the centre, a green bean bag was placed halfway to each end and the blue bean bag was placed at each end (See Fig 2). Three chairs were placed at the table (centre, left and right) and participants were asked to sit in the centre and try and reach, with their back touching the chairs, the red, green and blue bean bags (therefore demonstrating their own reaching span). Participants were then asked to stand up and were advised that they would be picking up a bean bag of a specific colour. They were then instructed to choose one of the chairs and sit down. Participants were not told which of the two bean bags of the specific colour they would have to pick up until they had selected a chair. The order of each colour and direction was randomised. After the completion of this task, participants were asked to head outside for the accuracy measurement task followed by the throwing task which were identical to *Session 1*.

FIGURE 5.

Table task setting. Participants entered the room and were asked to choose a chair to sit on depending on the colour of the bean bag they would have to reach for.

Participants who were not selected for the table task, were taken to the same room and were given a Sudoku exercise. They then went outside for the accuracy measurement and throwing task.

Analysis

Participants were expected to display similar behaviours in the first session of the experiment and the performance of the group subject to the training session was expected to change during the second session compared to the performance of the group doing the Sudoku task. In order to test this, we ran a 2x2x2 multivariate ANOVA to look for an interaction between the training group and their movement in second session. Additionally, we wanted to find out whether the means of each condition were statistically significant from each other and ran four paired samples t-tests.

Results

The aim of the current study was to determine whether a training session will bear an impact upon the behaviours and strategies of the participants dependent on the increased distance.

The accuracy of each participant was recorded to allow for a better understanding of participant behaviour and the optimal point to switch strategy was calculated given the accuracy measurement trials. This confirmed that participants should start focusing on one target at the expense of the other for the colours yellow and blue.

Multivariate factorial ANOVA

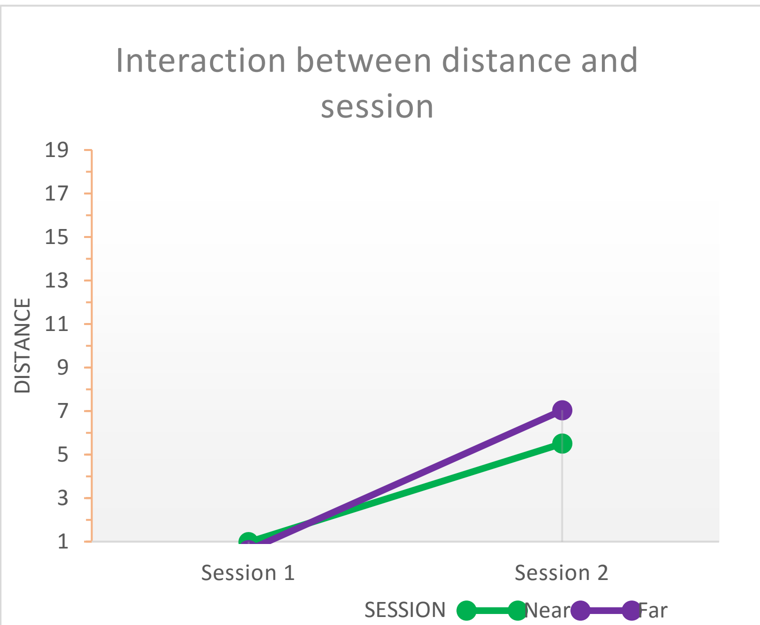

FIGURE 3.

Interaction between the session number and the distance participants moved to.

In order to test whether there was a difference in where people stood for far hoops compared to near hoops in both sessions depending on their group, we performed a one 2 x 2 x 2 multivariate factorial ANOVA. The between subjects training group involved two levels: Sudoku or table task. The within subjects factors were the session number (one or two, at a week apart) and the distance of the hoops from the centre, near including the red and green hoops whilst far included the yellow and blue hoops. We collapsed two hoops together to form two levels of the distance factor. Session one vs Session two overall difference was statistically significant showing that training did not affect performance and the overall small to medium group effect supports this conclusion ($p< .001$; $\eta_p^2= .040$; $F_{(1,18)}= .744$).

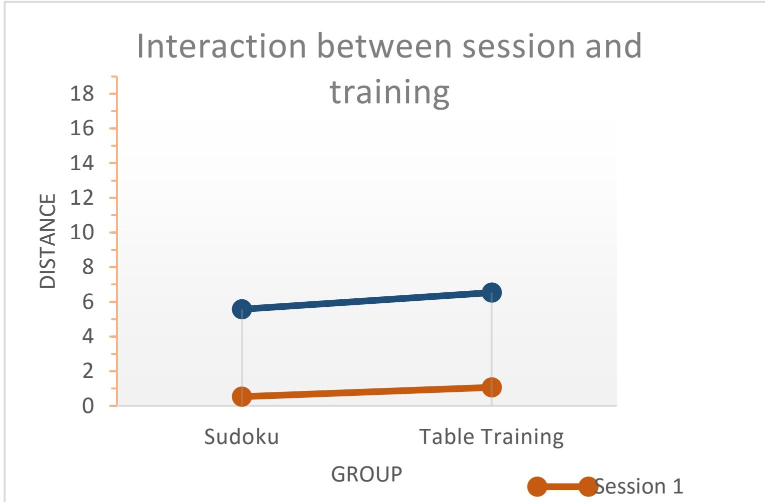

FIGURE 4.

Interaction between the session number and the group participants were in.

The effect of distance was found to be very large showing a statistically significant behaviour difference, regardless of the session number ($F_{(1,18)}= 7.463$; $p= .014$; $\eta_p^2= .293$) with participants changing their behaviour accordingly when distance increased.

The analysis showed a large effect when looking at the session performance, with a statistically significant difference between sessions ($F_{(1,18)}= 40.946$; $p< .001$; $\eta_p^2= .695$). The interaction between the distance of the target and the session number produced a very large effect ($\eta_p^2= .403$; $F_{(1,18)}= 12.167$; $p= .003$) supporting the possibility of the above mentioned learning effect, disregarding training as there was an overall increase in movement in both groups (See **Figure 3**). There was no significant interaction between session number and training group ($F_{(1,18)}= 2.081$; $p= .166$),(See **Figure 4**.) as well as no significant interaction between distance and training group ($F_{(1,18)}= .072$; $p= .791$),(See **Figure 5**) Following the results of the multivariate factorial ANOVA, a significant interaction between session number and distance was noted. Looking at

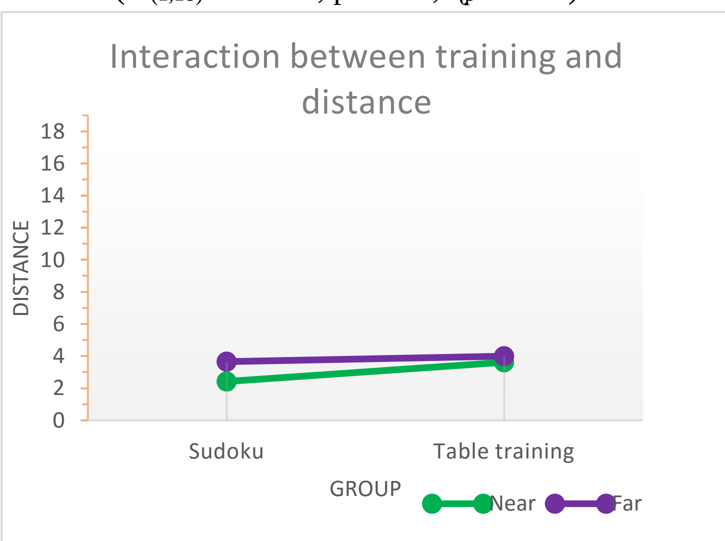

FIGURE 5.

Interaction between the group participants were in and the performance for the two distances.

the change in strategy and whether participants moved away from the centre more in session two than in session one, we analysed the mean distance from the centre and the furthest hoop for each participant and session. This showed a statistically significant difference in behaviour (See **Figure 6**), regardless of training ($F_{(1,18)}$= .25; p= .003) result which can be linked to the significant behaviour change observed in the session one far vs. session two t-test results. However, the overall interaction between distance, session and training group ($F_{(1,18)}$= .025; p= .876; η_p^2= .001) shows the training task did not influence performance in the second session, nor did it enhance the participants optimal strategy selection.

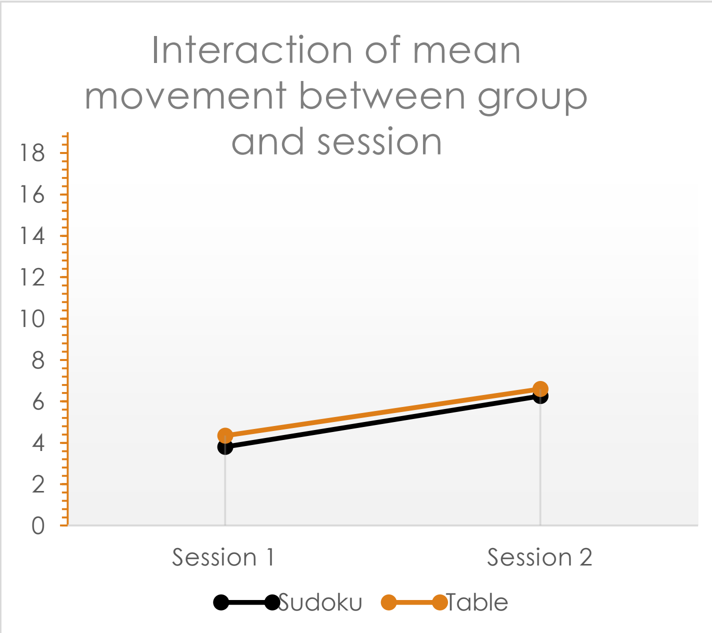

FIGURE 6.

Mean distance of far and near in participants moved was calculated and used for an interaction between the two groups and sessions.

Paired samples t-tests

In order to further look at the differences in performance between the two sessions and groups, we also performed four paired samples t-tests using SPSS:

To test whether there was a difference between where participants stood for far hoops compared to near hoops we looked at:

* *Session one distance near vs session one distance far* (N=20; $t_{(19)}$= -5.22; p< .001; SD=3.489; M=.980) resulting in a strongly statistically significant change of behaviour when participants faced a larger distance. This difference is also present in the previously mentioned ANOVA, showing that participants moved further away from the centre.
* *Session two distance near vs session two distance far* (N=20; $t_{(19)}$= -6.819; p< .001; SD=4.217; M=.605) with statistically significant results supporting the findings for session one.

* *Session one distance near vs. Session two distance near* (N=20; $t_{(19)}$= 2.241; p= .037; SD=.794; M=.980) showing a statistically significant change in strategy even for close hoops.
* *Session one distance far vs Session two distance far* (N=20; $t_{(19)}$= -3.525; p= .004; SD=.745; M=5.053) with a statistically significant difference in behaviour between sessions when distance was larger.

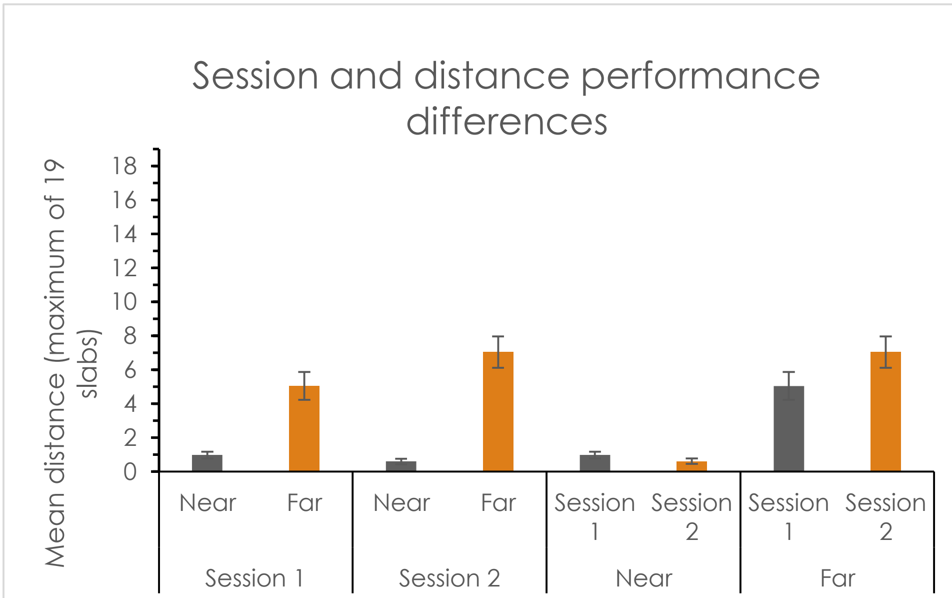

FIGURE 7.

The mean distance from center (0) to the furthest hoop (19) participants moved to throughout the trials in both sessions.

It should be noted that these t-tests did not exclude training group difference. It can therefore be concluded that the training task did not influence participant's strategy. However, given the results of the t-test, participant's behaviour changed with the difficulty of the task and whilst participants did not perform optimally for all trials, their chosen strategy was improved from one session to the other, suggesting a possible learning effect (See **Figure 7**).

Discussion

Previous literature has been primarily focused on optimal visual search, saccadic choice and fixation selection in both humans and animals however, there is only a limited number of research on optimality in human behaviour (Lee & Schwarz, 2010; Najemnik and Geisler, 2009).

The recent findings of Clarke and Hunt (2015) showing the prevalence of suboptimal behaviours in humans when faced with the option of investing all resources in one target or divide them across two possible goals have raised the question of whether a training task would enhance optimal strategy selection (Clarke and Hunt, 2015) The aim of the current study was to determine whether such a training session will influence the behaviours and strategies of the participants when the task difficulty increases, a point at which participants should change their strategy and invest all resources in one goal. Whilst participants chose a near optimal strategy in the second session, there was no difference in performance found between the group subject to training and the other group. Reinforced learning due to poor performance throughout the first session could account for the slight change in behaviour observed in the second session however, this is far from complete. If participants were learning to perform the task optimally, they would be approaching slab 19 in the second session trial but they are averaging less than 7 even in the training group.

In the table trials, used as a training task allowing participants to better understand the instructions of the experiment, all participants chose optimal strategies, showing that instructions were understood and the ability to make a logical decision was present.

The results of the t-tests revealed no systematic strategy improvement, leading to the possible conclusion that participants were not particularly optimal with or without the training and the hypothesis of the experiment was therefore not supported by the results of the study.

The results of this experiment are similar to the findings of Morvan and Maloney (2012) who suggested that the participants' failure to adapt their behaviour accordingly and perform optimally on the task could be associated to a chosen default behaviour that has been applied to the previous trials. All participants were subject to an accuracy set of trials where, whilst only standing in the centre, they were required to throw beanbags in corresponding hoops at different distances. According to Morvan and Maloney (2012), this could have influenced participants to exhibit a preference towards a default behaviour, even in later trials where they would have been expected to change strategies if distances increased.

The ability to make decisions is a core competence of both animals and humans acting and surviving in environments they might only partially understand. The theories of how decision making processes occur form a framework allowing us to understand and pose questions about optimal and near optimal behaviours (Kording, 2007; Mangel & Clark, 1989; Clarke & Hunt, 2015). Two main considerations of such theories are what the subject knows about the task and what they wish to accomplish. Participants understood the task and its goal in the present study however, the individual goal of each participant remains unknown. Whilst the perceived goal of the task was to successfully throw a bean bag in its corresponding hoop, participants could prioritise something other than the accuracy with a possibility of seeing the task as a personal challenge, biasing them towards performing the task in difficult circumstances and therefore not investing all resources towards just one goal. Morvan and Maloney (2012) show similar findings even when monetary reward is present, supporting the possibility of participant bias towards own priorities.

When trying to reach a decision, humans analyse if a particular event or task has been present in the past in order to reuse the solutions that were successful. This selection of past solutions involves a general learning process through which humans exhibit the tendency to use strategies that led to the best outcome previously (Erev & Roth, 1998). The behaviour of both groups of participants changed significantly in the second session of the study, behaviour which can be attributed to a learning process. Performing badly in the first session and having a week to reflect upon behaviours could lead participants to change their strategy in the second session. However, as noted earlier, the performance in the second session was still suboptimal. The improved yet still suboptimal behaviours exhibited in the second session could be an implication of the failure to adequately attribute consequences of decisions to the appropriate prior action as the outcome of the feedback cannot always be used to accurately update expectations to reflect ones experience. Kershold and Raajmakers (1997) argue that under such conditions, participants may gain control over the task and reach a performance constant but will not necessarily gain knowledge on how to improve such performance.

As noted by Clarke and Hunt (2015), there are many ways in which humans can exhibit suboptimal behaviours. The above mentioned explanations cannot account for all results however, they can all bear an impact on individual performance and behaviour. Given the optimal behaviours exhibited in the table trials, the question arising is why the optimal strategy is so easily disrupted in a more complex setting. Previous research has noted that humans do possess the ability to achieve near optimal visual search, allowing one to process the most important information out of the environment and considering potential decisions (Najemnik and

Geisler, 2005) however, the results of the present study lead to the conclusion that optimal behaviours can be affected by a multitude of implications, making the understanding of decision processes more difficult.

The present study refutes the idea that training could enhance optimal performance in complex tasks and opens the possibility of a reinforced learning theory. Further research efforts are needed in order to develop an effective understanding of optimal behaviour in decision making. It would be ideal to replicate the current study and introduce a longevity aspect. Several sessions at weeks apart might be required to test the reinforced learning theory to allow for a better understanding of behavioural changes throughout sessions.

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Appendices

APPENDIX A.

Paired samples t-test output for the differences between sessions and distances

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Session 1 - Near - Session 1 - Far	-4.073754	3.489937	.780374	-5.707094	-2.440413	-5.220	19	.000
Pair 2	Session 2 - Near - Session 2 - Far	-6.431350	4.217816	.943133	-8.405350	-4.457350	-6.819	19	.000
Pair 3	Session 1 Overall Scores - Session 2 Overall Scores	.355683	.794962	.177759	-.016371	.727736	2.001	19	.060
Pair 4	Session 1 - Near - Session 2 - Near	.374963	.748299	.167325	.024748	.725178	2.241	19	.037
Pair 5	Session 1 - Far - Session 2 - Far	-1.982633	2.726546	.609674	-3.258696	-.706571	-3.252	19	.004

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Session 1 - Near	.98021	20	.873195	.195252
	Session 1 - Far	5.05397	20	3.647045	.815504
Pair 2	Session 2 - Near	.60525	20	.725576	.162244
	Session 2 - Far	7.03660	20	4.168460	.932096
Pair 3	Session 1 Overall Scores	-.09962	20	.816951	.182676
	Session 2 Overall Scores	-.45530	20	.993372	.222125
Pair 4	Session 1 - Near	.98021	20	.873195	.195252
	Session 2 - Near	.60525	20	.725576	.162244
Pair 5	Session 1 - Far	5.05397	20	3.647045	.815504
	Session 2 - Far	7.03660	20	4.168460	.932096

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Session 1 - Near & Session 1 - Far	20	.296	.205
Pair 2	Session 2 - Near & Session 2 - Far	20	.019	.938
Pair 3	Session 1 Overall Scores & Session 2 Overall Scores	20	.630	.003
Pair 4	Session 1 - Near & Session 2 - Near	20	.575	.008
Pair 5	Session 1 - Far & Session 2 - Far	20	.764	.000

APPENDIX B.

Mixed design factorial ANOVA output for interactions of group, session and distance

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Distance	Sphericity Assumed	12.923	1	12.923	7.463	.014	.293	7.463	.734
	Greenhouse-Geisser	12.923	1.000	12.923	7.463	.014	.293	7.463	.734
	Huynh-Feldt	12.923	1.000	12.923	7.463	.014	.293	7.463	.734
	Lower-bound	12.923	1.000	12.923	7.463	.014	.293	7.463	.734
Distance * Group	Sphericity Assumed	3.604	1	3.604	2.081	.166	.104	2.081	.277
	Greenhouse-Geisser	3.604	1.000	3.604	2.081	.166	.104	2.081	.277
	Huynh-Feldt	3.604	1.000	3.604	2.081	.166	.104	2.081	.277
	Lower-bound	3.604	1.000	3.604	2.081	.166	.104	2.081	.277
Error(Distance)	Sphericity Assumed	31.168	18	1.732					
	Greenhouse-Geisser	31.168	18.000	1.732					
	Huynh-Feldt	31.168	18.000	1.732					
	Lower-bound	31.168	18.000	1.732					
Session	Sphericity Assumed	551.786	1	551.786	40.946	.000	.695	40.946	1.000
	Greenhouse-Geisser	551.786	1.000	551.786	40.946	.000	.695	40.946	1.000
	Huynh-Feldt	551.786	1.000	551.786	40.946	.000	.695	40.946	1.000
	Lower-bound	551.786	1.000	551.786	40.946	.000	.695	40.946	1.000
Session * Group	Sphericity Assumed	.971	1	.971	.072	.791	.004	.072	.057
	Greenhouse-Geisser	.971	1.000	.971	.072	.791	.004	.072	.057
	Huynh-Feldt	.971	1.000	.971	.072	.791	.004	.072	.057
	Lower-bound	.971	1.000	.971	.072	.791	.004	.072	.057
Error(Session)	Sphericity Assumed	242.569	18	13.476					
	Greenhouse-Geisser	242.569	18.000	13.476					
	Huynh-Feldt	242.569	18.000	13.476					
	Lower-bound	242.569	18.000	13.476					
Distance * Session	Sphericity Assumed	27.791	1	27.791	12.167	.003	.403	12.167	.909
	Greenhouse-Geisser	27.791	1.000	27.791	12.167	.003	.403	12.167	.909
	Huynh-Feldt	27.791	1.000	27.791	12.167	.003	.403	12.167	.909
	Lower-bound	27.791	1.000	27.791	12.167	.003	.403	12.167	.909
Distance * Session * Group	Sphericity Assumed	.056	1	.056	.025	.876	.001	.025	.053
	Greenhouse-Geisser	.056	1.000	.056	.025	.876	.001	.025	.053
	Huynh-Feldt	.056	1.000	.056	.025	.876	.001	.025	.053
	Lower-bound	.056	1.000	.056	.025	.876	.001	.025	.053
Error(Distance*Session)	Sphericity Assumed	41.114	18	2.284					
	Greenhouse-Geisser	41.114	18.000	2.284					
	Huynh-Feldt	41.114	18.000	2.284					
	Lower-bound	41.114	18.000	2.284					

Distance	Linear		12.923	1	12.923	7.463	.014	.293	7.463	.734
Distance * Group	Linear		3.604	1	3.604	2.081	.166	.104	2.081	.277
Error(Distance)	Linear		31.168	18	1.732					
Session		Linear	551.786	1	551.786	40.946	.000	.695	40.946	1.000
Session * Group		Linear	.971	1	.971	.072	.791	.004	.072	.057
Error(Session)		Linear	242.569	18	13.476					
Distance * Session	Linear	Linear	27.791	1	27.791	12.167	.003	.403	12.167	.909
Distance * Session * Group	Linear	Linear	.056	1	.056	.025	.876	.001	.025	.053
Error(Distance*Session)	Linear	Linear	41.114	18	2.284					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	935.169	1	935.169	60.893	.000	.772	60.893	1.000
Group	11.432	1	11.432	.744	.400	.040	.744	.129
Error	276.438	18	15.358					

a. Computed using alpha = .05

APPENDIX C.

Mixed design factorial ANOVA plots for interactions of group and session, group and distance and distance and session.