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An Experimental Test of the Endowment Effect

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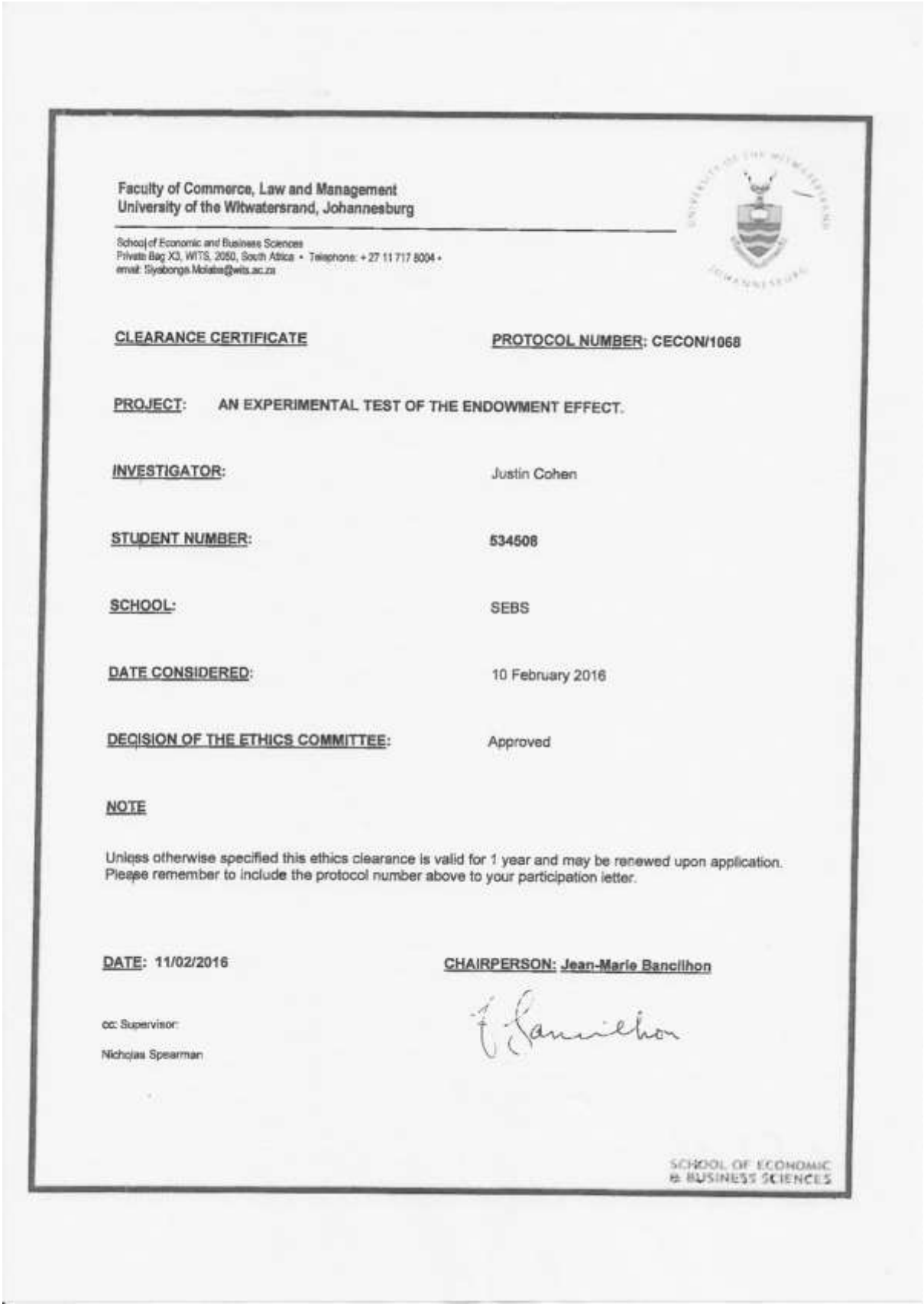

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PROJECT: AN EXPERIMENTAL TEST OF THE ENDOWMENT EFFECT.

INVESTIGATOR: Justin Cohen

STUDENT NUMBER: 534508

SCHOOL: SEBS

DATE CONSIDERED: 10 February 2016

DECISION OF THE ETHICS COMMITTEE: Approved

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Abstract

In this study, I use a computer game based lab experiment to investigate the existence of the Endowment Effect. Previous empirical evidence has been criticised for failing to adequately account for the effects of transactions costs and other frictions. The structure of the game used in this study allows me to control for these effects, and the results provide evidence in support of the existence of an Endowment Effect. The effect is found to be stronger when transactions costs are present.

Keywords: Endowment Effect, Experiment, Behavioural Economics, Economics

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1. Introduction

In this report, I investigate the question: "Can evidence of an Endowment Effect be found, using a methodology that addresses the concerns of previous studies on the topic?". The Endowment Effect is the hypothesis that economic agents place a higher value on objects they are endowed with, simply because the objects are in the agents' possession, *ceteris paribus* (Thaler, 1980; Kahneman, Knetsch, & Thaler, R, 1990). This leads to 'market inefficiencies' as buyers and sellers have different valuations of the same object (Morewedge & Giblin, 2015). The seminal work on the Endowment Effect is a paper by Kahneman et al. (1990) who conduct an experiment and test the Endowment Effect against the Coase theorem. The Coase theorem contends that initial endowments are irrelevant to the outcome in the absence of transaction costs (Tversky & Kahneman, 1991).

Most of the previous studies that have examined the Endowment Effect use a valuation technique which employs two measures: Willingness to Accept (WTA) and Willingness to Pay (WTP). WTP is the value that an individual is willing to pay to receive an object and WTA is the amount that an individual would be willing to accept in payment to give up that same object (Kahneman, et al., 1990; Shogren & Shin, 1994; Horowitz & McConnell, 2002; Horowitz & McConnell, 2003; Hanemann, 1991; Carmon & Ariely, 2000). Standard neoclassical theory suggests that at the margin an individual's WTP and WTA for an object should be the same and numerous studies have used any disparity between these two measures as *prima facie* evidence of an Endowment Effect. There are however, three key shortcomings with this valuation technique:

1. The sensitivity of the WTP and WTA measures to the type of good and market conditions (Horowitz & McConnell, 2002): experiments involving goods that are non-market (goods that cannot be traded in a market) exhibit the largest disparity, followed by experiments that involve 'ordinary private goods' (Horowitz & McConnell, 2002).

2. The sensitivity of the measures to the availability of substitutes (Shogren & Shin, 1994): no evidence of an Endowment Effect can be found when substitutability is controlled for, and

any evidence of an Endowment Effect that is found is heavily influenced by the substitutability of the goods in question (Shogren & Shin, 1994 and Hanemann, 1991).

3. WTP and WTA gaps may not reflect an Endowment Effect as the techniques used may not adequately capture human preferences (Plott & Zeiler, 2005).

These shortcomings have been used to contend the Endowment Effect's existence. The computer game-based lab experiment presented in this paper is a means of addressing these shortcomings. The experiment does not make use of WTP and WTA as measures: the game makes use of goods (coins) whose value is not determined by the forces of supply and demand as the value of the goods is solely based on the payoff structure of the game; the goods are unique to the game and designed so that participants are unlikely to have any inherent preferences for either of the good types; the goods were designed to be perfect substitutes to control for substitutability.

The computer-based lab experiment is also designed to examine whether the Endowment Effect is present in both the presence and absence of transaction costs. This is done to examine the Endowment Effect against the Coase Theorem which studies endowments in the absence of transaction costs.

The results of my study find evidence of an Endowment Effect. Participants place a higher value on goods they have been endowed with over perfect substitutes which they have not been endowed with. My paper provides evidence of an Endowment Effect when substitutability, type of good, and market setting are controlled for, thereby addressing several shortcomings in the existing literature. Furthermore, my paper not only controls for transaction costs but also isolates its effect on the Endowment Effect.

This paper is organised as follows: section 2 provides a motivation for the study. Section 3 reviews the literature on the Endowment Effect; section 4 offers a methodology to test the Endowment Effect; the methodology explains in detail the experiment - including its outline, aims and construction. Section 5 provides the empirical strategy employed to analyse the experimental

data. Section 6 presents the results and section 7 includes a discussion on these results. Section 8 concludes the paper.

2. Motivation

When I examined the literature on the topic of the Endowment Effect, it became apparent that experimental evidence of the Endowment Effect has centred on two measures: WTA and WTP. Although these measures are used broadly, there are many criticisms regarding them, including their sensitivity to the type of good, the setting in which the good is offered and the substitutability of the goods used in the study. It is because of these criticisms, that the existence of the Endowment Effect is challenged. This has led me to ask the question: “If the shortcomings of previous experiments were addressed, could I find evidence that an Endowment Effect exists?”. I hope to test the robustness of the theory of the Endowment Effect by subjecting it to experimentation using a new methodology. To answer this question, I have used a disparate methodology that does not make use of WTA-WTP, market goods and one that controls for substitution effects.

3. Literature Review

Since the latter half of the 20th century, many behavioural economists began to observe that individuals appear to place a higher value on objects or things that they own and are willing to pay a premium to retain that object, regardless of the length of time in which they have owned it (Thaler, 1980; Kahneman, Knetsch, & Thaler, R, 1990). This phenomenon has been formulated into a hypothesis known as the 'Endowment Effect' and is a bias which changes the way individuals make decisions.

The Endowment Effect is traditionally measured using Willingness to Accept (WTA) and Willingness to Pay (WTP). WTA and WTP are both measures of the value of a good: WTP is the amount that an individual is willing to pay to purchase an object and WTA is the amount that an individual would be willing to receive in payment for selling that same object (Kahneman, et al., 1990; Shogren & Shin, 1994; Horowitz & McConnell, 2002; Horowitz & McConnell, 2003; Hanemann, 1991; Carmon & Ariely, 2000). For a single object, standard economic assumptions imply that the WTA and the WTP should be the identical since exchange will lead to the most efficient outcome (Kahneman, et al., 1990; Willig, 1976; Coase, 1937; Coase, 1960). Any disparity between the two values is indicative of an underlying bias (Kahneman, et al., 1990; Shogren & Shin, 1994; Horowitz & McConnell, 2002; Horowitz & McConnell, 2003; Hanemann, 1991; Carmon & Ariely, 2000). There is considerable evidence in favour of a WTP-WTA gap (Horowitz & McConnell, 2002; Horowitz & McConnell, 2003; Hanemann, 1991; Carmon & Ariely, 2000). A disparity between WTA-WTP means that markets do not clear efficiently as the pricing between the demand side and supply side is different (Morewedge & Giblin, 2015). Thaler (1980), Kahneman, et al. (1990) and Kahneman, et al. (1991) contend that such a disparity is caused by the Endowment Effect.

The seminal work on the Endowment Effect is a paper by Kahneman et al. (1990). In this paper, the authors conduct an experiment and test the Endowment Effect against the Coase theorem

(the Coase theorem contends that initial endowments are irrelevant to the outcome in the absence of transaction costs (Tversky & Kahneman, 1991)). In the experiment conducted by Kahneman et al. (1990), half the participants are endowed with a 'consumption object', in this case, mugs. A market is created for these mugs; participants who were given mugs became the sellers whilst the other half became the buyers (Kahneman et al., 1990). The sellers were given a range of prices and asked whether they would sell the mug at each price or keep the mug; the buyers (those who were not given a mug) were asked whether they would buy the mug at each of the prices. With voluntary exchange, it is expected, in the absence of an Endowment Effect, that half of the mugs would sell (as the participants' demand and supply curve should be perfect reflections of one another). However, the actual volume of mugs that traded was considerably lower than half. The median price for those who were willing to sell was roughly twice as high as the median price of those who were willing to buy which led to under-trading (Kahneman et al., 1990; Tversky & Kahneman, 1991).

There is a large body of experimental and empirical evidence on the Endowment Effect (in addition to the body of evidence presented for WTA-WTP discrepancies). One such test found evidence of the Endowment Effect in Capuchin monkeys (Lakshminaryanan, Chen, & Santos, 2008) and chimpanzees (Brosnan, Jones, & Lambeth, 2007), suggesting that such a bias is not just limited to humans. Some of the earliest examples of experiments that found evidence consistent with the Endowment Effect were Knetsch and Sinden (1984) and Knetsch (1989) whilst some reputed these early demonstrations because participants were not exposed to market conditions (Coursey, Hovis, & Schultze, 1987) and because of habits associated with bargaining (Knez, Smith & Williams, 1985). Later experiments, such as the one described above (Kahneman et al., 1990), found evidence of the Endowment Effect in a market setting (Loewenstein & Kahneman, 1991).

3.1.What challenges have been faced?

An important critique of Tversky & Kahneman (1991) finds that differences in the WTP and the WTA tend to be removed when goods are highly substitutable whilst this difference persists in

goods that are imperfect substitutes (Hanemann, 1991; Shogren & Shin, 1994). The authors argue that the experiment in Kahneman et al. (1990) produces the results it did because of an inability to substitute the goods in question (Hanemann, 1991; Shogren & Shin, 1994), in other words, it created a situation where there is the capacity for an abundance of goods, however this capacity is purposefully reduced to create scarcity thereby increasing the value of the artificially scarce item (Hanemann, 1991; Shogren & Shin, 1994). Substitutability is an important challenge that needs to be controlled for, for a thorough experimental examination of the Endowment Effect.

Zeiler and Plott (2004) argue that even when a gap between the WTA and WTP is observed (they also found that such a gap is not only observable but also replicable), this gap is not indicative of an Endowment Effect but rather it is sensitive to the procedures used in the experiment. These results from these procedures may be influenced by the participants' conception of the subject [1] (Zeiler & Plott, 2004). When subject misconception is controlled for, there is no evidence of a gap between WTA and WTP (Zeiler & Plott, 2004). Different procedures that were listed included (i) eliciting valuations based on different market settings, (ii) describing the optimal method of responding to the experiment, and the (iii) different ways of measuring the WTA-WTP gap (Zeiler & Plott, 2004). One interpretation for the disparity between WTA and WTP is that the methods employed to test the WTA-WTP disparity do not measure preferences accurately (Horowitz & McConnell, 2003).

The literature contains numerous studies that find no evidence of the Endowment Effect. However, these studies use the shortcomings of the (WTA and WTP) measures rather than the shortcomings of the theory as the basis for their critiques. This demonstrates a need for an alternative methodology to be used; one that addresses the shortcomings of the WTA and WTP measures.

[1] 'Subject Misconception' (Zeiler & Plott, 2004) occurs when research subjects misunderstand the elicitation techniques used in a study.

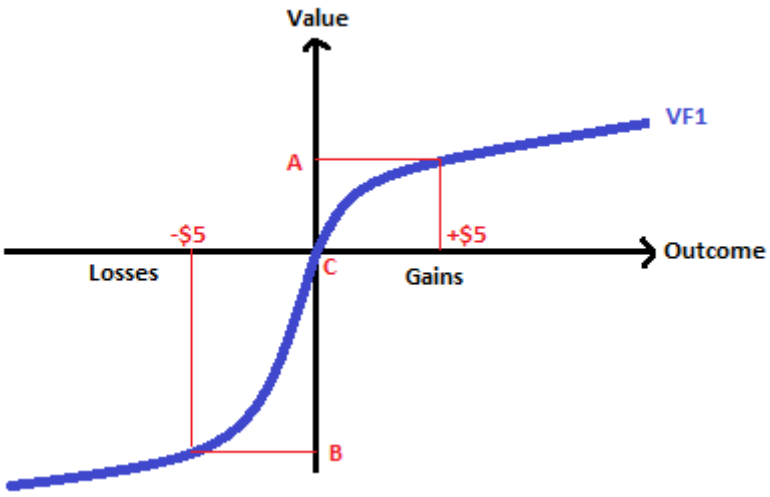
3.2.Can a suitable explanation for the Endowment Effect be found?

There are two mains competing schools of the thought that explain the Endowment Effect: behavioural economics and classical economics. Other schools of thought include psychology, cognitive processing theories, and even evolutionary arguments.

3.2.1. Behavioural Economics

The main behavioural economic hypothesis that has been offered to explain the Endowment Effect is Prospect Theory (Kahneman & Tversky, 1979). Individuals base their decision on the gains or losses relative to a reference point (Kahneman & Tversky, 1979). It is this reference state that gives rise to what an individual will regard as a loss – an outcome below the reference state – and as a gain – an outcome above the reference state – and it is this reference-dependence that affects an individual's preferences (Kahneman & Tversky, 1979). Furthermore, losses are more impactful than gains and this is derived from loss aversion. Loss aversion is the hypothesis that the negative effect of a loss or disadvantage on an individual is greater than the positive effect or advantage of an equal gain (Tversky & Kahneman, 1991). This suggests that an individual is then 'averse' to losses.

Figure 1: Prospect Theory (Loss Aversion)



Loss aversion is illustrated in Figure 1. The value function (VF1) is convex for losses and concave for gains. Furthermore, the value function is steeper for losses than it is for gains. The value of a gain (+$5) is equal to the distance between A and C. The value of a loss (-$5) is equal to the distance between B and C. The distance between B and C is greater than the distance between A and C, in other words, an individual is averse to losses. An individual will change their behaviour depending on whether an outcome is framed as a loss or framed as a gain. With respect to the Endowment Effect, a person receiving an object would frame the outcome as a gain whereas if that person had to give up that object, this outcome would be framed as a loss. This means a person is less inclined to give up an object than to receive it; this is a possible explanation or the Endowment Effect.

In the experiments conducted by Kahneman et al. (1990), those who were endowed with the mug considered selling a mug as a loss and those buying the mug as a gain, so those selling the mug require higher compensation for the mug. Tversky and Kahneman (1991) argue in the context of a WTA-WTP disparity that loss aversion may affect both: WTA is derived from the individual giving up the good and WTP is derived from the individual purchasing the good; one would expect that a buyer of a good views money as a loss leading to a reluctance to purchase a good and a seller would be reluctant to sell as the item they are selling is viewed as a loss; however, Kahneman et al. (1990) argue that money isn't viewed as a loss as money is simply a medium of exchange so there is (still) greater reluctance to sell than to buy. The results from studies of brain activities find evidence consistent with loss aversion and positively correlate with disparities between WTA and WTP (Morewedge & Giblin, 2015; Knutson, et al., 2008; De Martino, et al., 2009; Saqib, et al., 2010; DeWall, et al., 2015).

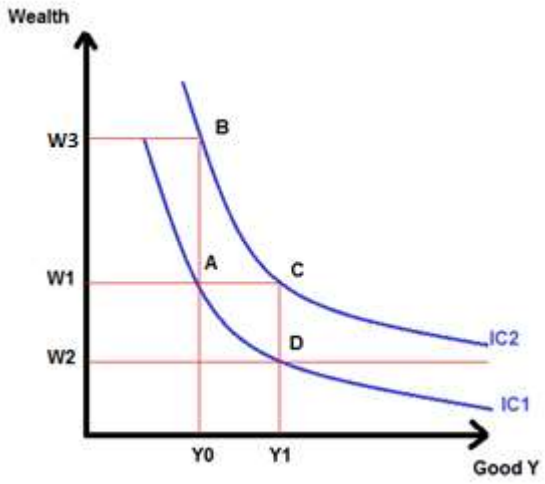
3.2.2. Neoclassical Economics

Hanemann (1991) offered a neoclassical response to the findings by Kahneman, et al. (1990). Hanemann (1991) found that substitution effects greatly impact the WTA-WTP gap and such a gap

can range between zero and infinity through differences in the substitutability of the goods used in the experiment. Hanemann (1991) found that a WTA-WTP gap is only close to zero for goods that are very close substitutes and increases as goods become less substitutable. Shogren & Shin (1994) back up Hanemann's (1991) findings that the Endowment Effect is caused from the 'inability to substitute goods' as they observe no WTA-WTP gap in their experiments when substitutability is accounted for.

Shogren & Shin (1994) also offer an elegant depiction of Hanemann's (1991) neoclassical explanation: Hanemann (1991) looks at the scenario in which wealth and a certain good, Good Y, were substitutes where one would need to give up some wealth to acquire more of Good Y, to explain the WTA-WTP disparity (here hypothesised to be an Endowment Effect). Hanemann's (1991) argument is as follows (please refer to figure 2). An individual is endowed with wealth (W) and Good Y. Moving them from A to C, their wealth does not change but the amount of good Y they own has (Y0 toY1). For the individual to obtain Y1 without shifting the indifference curve, they would be willing to give up a certain amount of wealth (W1 to W2). The gap between W2 and W1 is equal to their WTP. W1 to W2 is the maximum they are willing to pay. Now, let's assume an individual starts off at point C and is required to give up good Y (Y1 to Y0). For them to accept this reduction in the amount of Good Y, they require compensation. The amount of compensation is equal to the distance between W3 and W1 such that they remain on their original indifference curve (IC2). W3 to W1 is the minimum they are willing to accept. The distance between W1 and W2 is smaller than the distance between W3 and W1; the WTA is larger than the WTP. In other words, when a good does not have many substitutes, 'a gain may be moderately valuable but a loss could be irreplaceable' (Horowitz & McConnell, 2003).

Figure 2: Neoclassical Explanation of the WTA-WTP gap



Horowitz & McConnell (2002) and Horowitz & McConnell (2003) identify the main shortcoming of the neoclassical explanation: evidence of the substitution effects is hard to come by as many of the goods used in the neoclassical studies are not available in the market and there are insufficient measures of the elasticity of substitution in the market.

3.2.3. Other explanations of the Endowment Effect.

In response to Loss Aversion's inability to identify the cognitive processes associated with the Endowment Effect, several theories have been developed that do: these include psychology, cognitive processing theories, and even evolutionary arguments.

'Ownership Account'

It is argued that loss aversion and Prospect Theory do not account for the Endowment Effect but it is purely the ownership of an object which increases its value (Morewedge, Shu, Gilbert, & Wilson, 2009). Individuals associate owning goods with themselves which is why individuals are reluctant to give them up; rather than the actual pain of losing those goods (Morewedge, Shu, Gilbert, & Wilson, 2009). Morewedge, Shu, Gilbert, & Wilson (2009) argue that most studies confound ownership and loss aversion because in those experiments, sellers are always owners. By

making the buyers the owner and not the sellers, Morewedge, Shu, Gilbert, & Wilson (2009) could find no evidence of an Endowment Effect. Morewedge, Shu, Gilbert, & Wilson (2009) conclude from this that ownership rather than loss aversion account for the Endowment Effect. Support for this theory is provided by Morewedge & Giblin (2015) and Maddux, et al. (2010).

Cognitive processing theories

Cognitive processing theories argue that the Endowment Effect can be explained through the information that the brain 'spontaneously' processes (Morewedge & Giblin, 2015). The brain 'spontaneously' makes reasons available to a buyer to keep one's money rather than buy a good and the brain 'spontaneously' makes reasons available to a seller to keep their good rather than sell it (Morewedge & Giblin, 2015). As sellers are more likely to think of reasons to keep their good and buyers more likely to think of reasons to keep their money, there will be a WTP-WTA disparity and an Endowment Effect. This cognitive processing theory is inconsistent with Loss Aversion as it does not assume that buyers and sellers process the same information regarding a decision (Morewedge & Giblin, 2015).

Evolutionary Arguments

Evolutionary arguments hypothesise that the Endowment Effect is a result of natural selection: an Endowment Effect (a preference for goods that an individual owns) increases an individual's bargaining power in trades. As the individual now has access to more resources, the Endowment Effect has a positive effect on that individual's chance of survival (Huck, Kirchsteiger & Oechssler, 2005). The behavioural bias is then passed down to future generations who are now fitter (in an evolutionary sense) increasing the proportion of that bias in the population. In other words, the Endowment Effect is simply a 'hard-wired' behavioural bias (Huck, Kirchsteiger & Oechssler, 2005). However, Morewedge & Giblin (2015) find that is it unlikely that evolutionary arguments explain the Endowment Effect.

The Endowment Effect is a phenomenon that has been well studied by various schools of economic and psychological thinking. There is a considerable body of evidence used to both support and reject the Endowment Effect's existence. The literature finds that evidence of an Endowment Effect cannot be found when substitutability, the type of good and its market as well as the procedures used in the experiments are controlled for. Furthermore, WTA and WTP may not capture preferences accurately.

4. Methodology

4.1. Background

4.1.1. Participants

There were thirty-one participants in the study. Four of the thirty-one participants attended a session held in a computer laboratory at University of the Witwatersrand. The remaining twenty-seven participants attended one-on-one sessions. Participants for the session held in the computer laboratory were invited through a poster disseminated on campus as well as by-word-of-mouth. The remaining participants were individuals I know personally. This had an impact on the demographics of the individuals who participated in the study. Of the participants who took part in the study:

Age:

- 5 were between the ages of 18 and 21;
- 14 were between the ages of 22 and 25;
- 6 were between the ages of 26 and 29;
- 6 were older than 30.

Gender:

- 54,8% (17) of the participants identified as male and 45,2% (14) of the participants identified as female.

Education:

- All participants surveyed had some level of tertiary education.
    - 3 were in the process of obtaining a bachelor degree;
    - 12 participants held a bachelor degree;
    - 14 participants held an honours degree;
    - 2 participants held a master's degree.

4.2. Participation in the study

Participants played a custom-made computer game (in the form of an executable file). The game was preloaded on the computers used by the participants. The decisions that participants made in the game were saved onto a database. The appendix (Appendix A5.1.) describes the data that was captured.

Each participant played a computer game. In the game, a participant was endowed with four electronic coins which they could flip. The coins were two-sided with either the "heads" or the "tails" side of each coin facing upwards representing the two coin types.

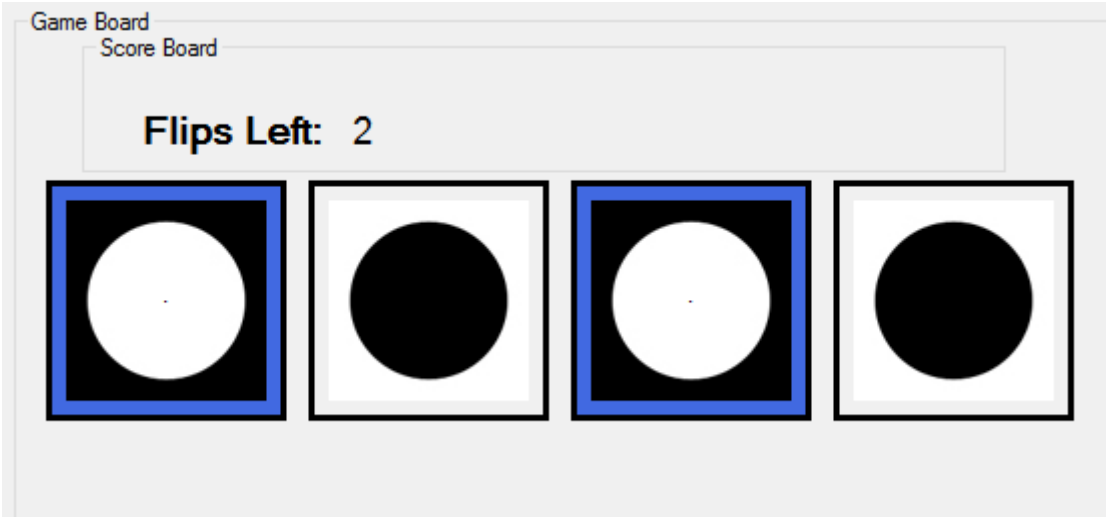
Figure 3: Coin types

Heads Tails



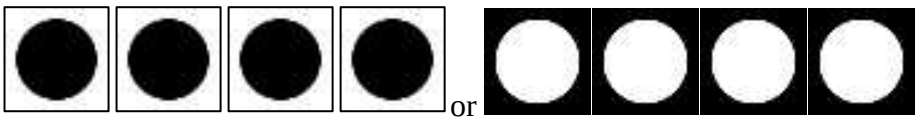
The objective of the game was to flip the coins in an attempt to achieve a combination (bundle) of coins whereby all four coins were of the same type ("four-of-a-kind"). The participant had three attempts (rounds) to flip the coins. A participant could flip any number of coins per round. A participant could choose how many coins to flip in each round and did not need to flip all four coins. A participant could choose which coins to flip and which to keep aside by selecting the coins they wished to keep aside.

Figure 4: Selected Coins (highlighted in blue)



Coins that were selected were not flipped whilst they remained selected. The reason why a participant would have chosen to keep coins aside was to accumulate as many coins of one type over the three rounds in order to achieve a bundle of four-of-a-kind. The game was won if all four coins were of the same type.

Figure 5: Four-of-a-kind winning bundles



If the participant did not achieve four-of-a-kind after three completed rounds, the participant lost the game.

A detailed step-through of how the game was played can be found in Appendix A2.

4.3. Assumptions.

The analysis is premised on two assumptions about how rational participants played the game:

1. Participants would only keep aside one type of coin in any round of play:

   a. If a participant kept aside more than one type of coin, they would be unable to obtain “four-of-a-kind”.
      i. The data supports this assumption: of the 31 participants playing the game 50 times each, totalling 1550 games played, there were only 6 instances where participants selected more than one coin type in a single round (0.39%).
2. Participants would keep aside the type of coin that appeared the most in each round.
   a. The basis for this is that it gave the participant the highest chance of winning the game.
      i. The data supports this: there were only 53 instances where participants did not adhere to this assumption (3.4%).

4.4. The purpose of the Game

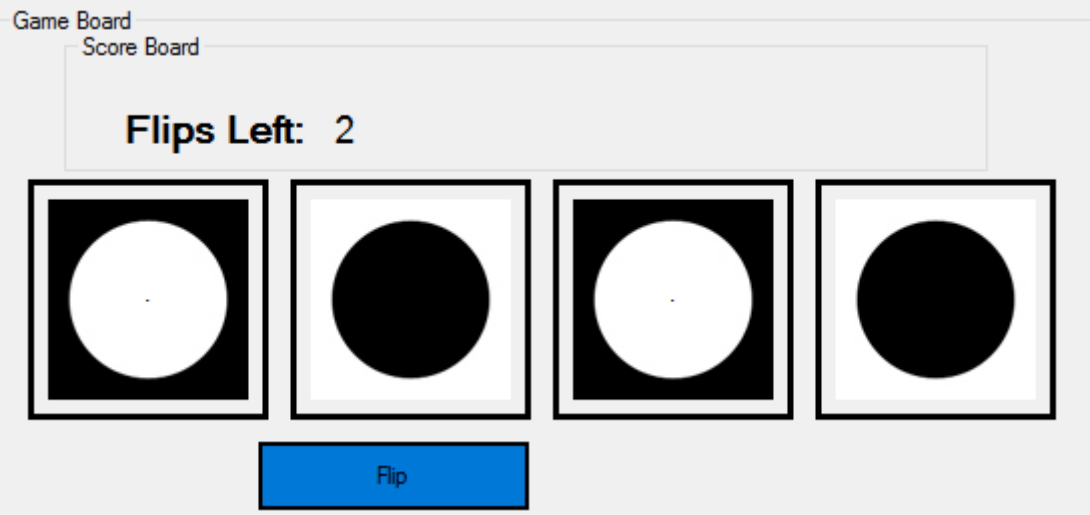
The game’s purpose was to endow a participant, and to then have that participant choose between that endowment and a perfect substitute and see which of the two the participant preferred. The participant’s endowment was their *choice* of coin bundle. By choosing a particular bundle the participant was endowed with that *choice*. If there was no Endowment Effect, they would have been indifferent between the two choices. This is the null hypothesis (H_0) that is tested. If there was an Endowment Effect, they would adhere to that choice more often than choosing a perfect substitute. This is the alternative hypothesis (H_1). The intuition here is that an Endowment Effect would increase the value of their initial choice (their endowment), simply because they were now endowed with it.

To test this, the participants were presented with a bundle of two pairs of each coin type in the second round at which point the participant must *choose* which pair of coin types to keep aside. The two unselected coins are then flipped and in the third round the participant is presented with exactly the same bundle of two pairs and must again *choose* which of the coin types the participant

wishes to keep aside before the final flip.[2] These two choices are at the heart of this study as discussed below.

There were four coins in total. The coins formed different bundles of coins of the same type (two pairs, three-of-a-kind and four-of-a-kind). The only time the participant was expected to be indifferent in their choice was if the participant was faced with a decision between two-pairs. This is confirmed by the results as discussed in section 7.

Figure 6: A bundle of two perfect substitute pairs

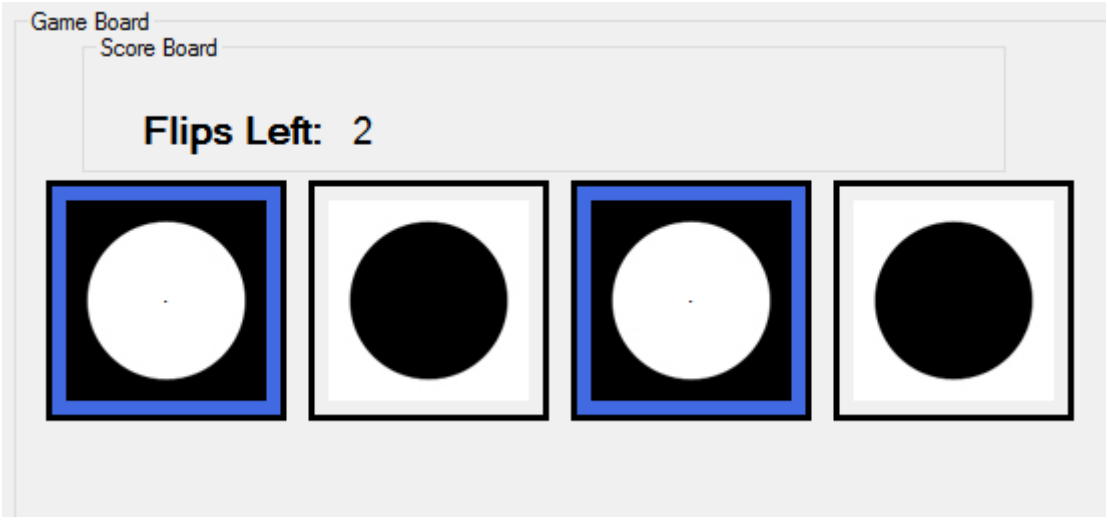


Each pair (pair 1 was ●● and pair two was ○○) was a perfect substitute for the other, they both consisted of two coins and were equally likely to lead to "four-of-a-kind" in subsequent rounds (a full breakdown of the value of each coin is provided in the Appendix, See Appendix A3). Furthermore, both pairs formed part of the participants bundle; both are presented to the participant who has to select a pair to keep (see figure 6). There should have been no preference for either pair at this stage and the participant should have been indifferent between the pairs (please the 'The

[2] Since the game consisted of four, two-sided coins, the participant was presented with various bundles in each round (all the available bundles are listed in Appendix A3). In any particular game a participant would see some series of bundles across the three rounds. The study only focuses on one particular series of bundles in the analysis: the series of bundles whereby a participant obtained a bundle of two pairs in round two, followed by a bundle of two pairs in round three.

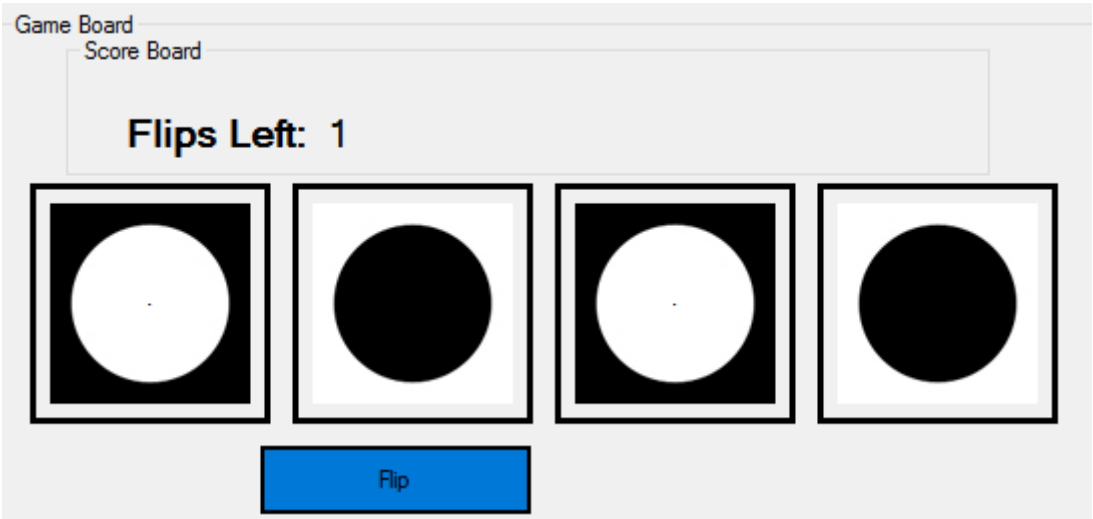
Control' in Section 7). For this example, it is assumed that the participant chose to keep aside and therefore selected the two tails coins.

Figure 7: A selected bundle pair (Round Two)



This is key to the study: the coins that the participant selected (see figure 7) to keep aside then represented the participant's choice endowment, and this bundle pair was the visual representation of that endowment going into the next round. The participant then selected 'Flip'and the two heads were flipped. At this point the particiant was presented with the same bundle as the previous round.

Figure 8: Round Three, prior to any selection



In round two, a participant chose between two pairs. In round three, a participant was once again given a choice to make between two pairs. The pair initially chosen in round two represented the endowment. The game was designed so that a participant faces these choices (the participant faced other choices but those are irrelevant to the study, please see the explanation in the Appendix, A3). In the absence of any endowment effect, the participant should have been indifferent between the two pairs and have been equally likely to choose either pair to be keep aside before once again flipping the unchosen coins. Evidence of an endowment effect would reflect in a bias towards the choosing the pair of coins chosen in the previous round. This hypothesis provides the basis for the analysis (see Section 5 below).

4.5. Transaction Costs

Transaction costs play a large role in the literature: The Endowment Effect was tested against the Coase Theorem in the seminal work on the topic. The Coase Theorem contends that initial endowments do not matter to an outcome in the absence of transaction costs. The game was therefore designed with two versions in order to control for whether the presence of transaction costs influenced any evidence of an endowment effect. Each player played both versions of the game. In the game, the transaction cost manifested itself in two ways: firstly, the effort required to select a coin and secondly, the effort required to deselect a coin.

In the first version of the game, coins were automatically deselected after each flip (see figure 9 below). Whether a participant chose to reselect the pair representing their endowment from the previous round, or chose a different pair, the act of selecting was the same for both choices and would have no influence on their choice. In the second version of the game (see figure 10 below), there was an added transaction cost associated with changing a choice. Participants in this version, needed to actively deselect any coins they had previously kept aside should they have wished to change their selection (selected coins were highlighted in blue). It was costlier for a participant to change their selection. Any evidence of a possible Endowment Effect would then have been

confounded by the effect of this transaction cost. An individual may have simply wanted to avoid the effort (transaction cost) of changing their choice. Having one version of the game with no transaction cost differentials and a second version of the game with added transaction cost differentials allowed me to compare the two versions and control for the effect of the transaction costs.

Figure 9: The choice faced by a participant during the third round of the game in version one of the game

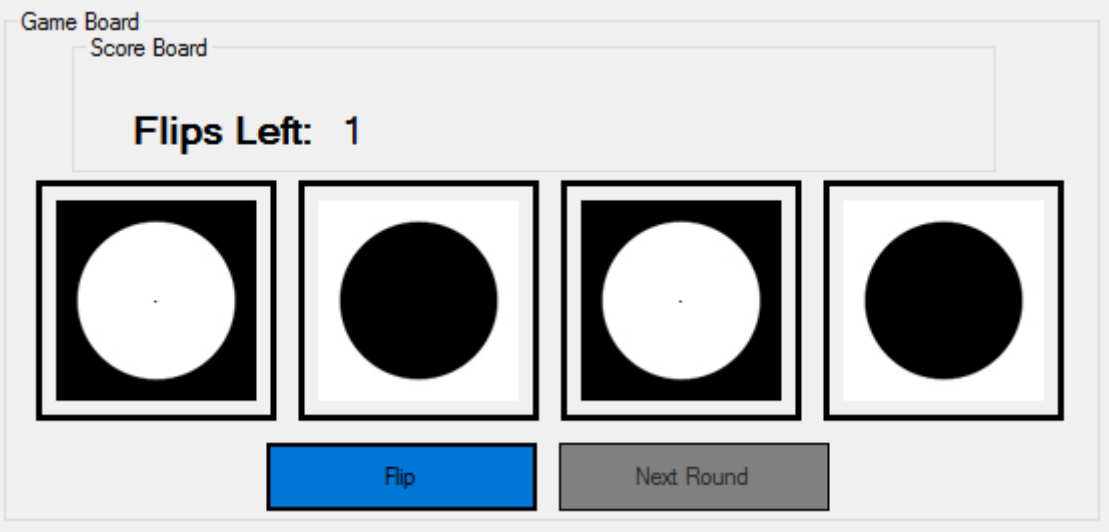
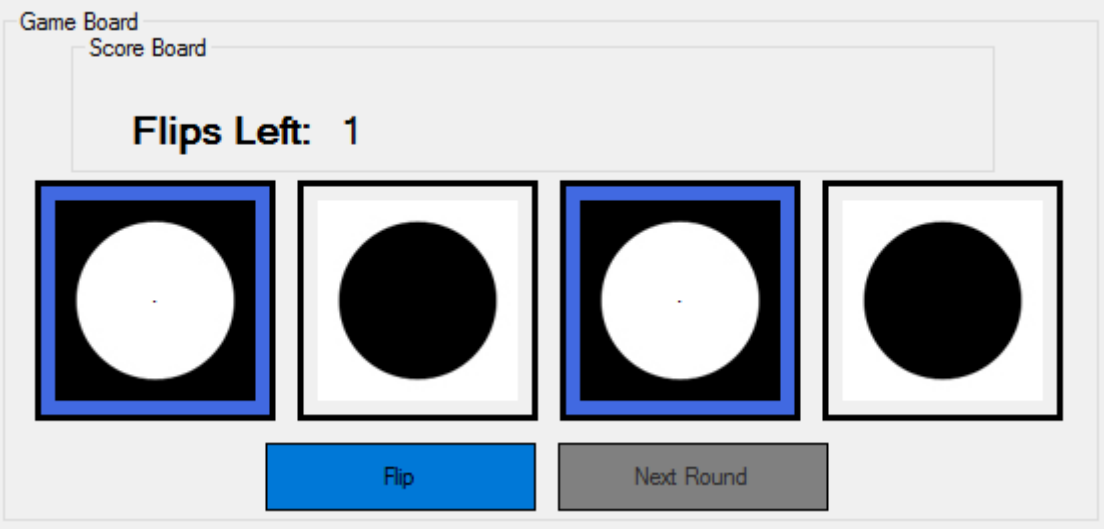


Figure 10: The choice faced by a participant during the third round of the game in version two of the game



5. Analysis

The participant made two decisions in the game: firstly, the participant chose between two pairs in the second round and secondly, the participant chose between two pairs in the third round. The important difference between the two decisions was that no pair in the second round was part of their endowment whereas in the third, one of the pairs did form the participant's endowment. The pair that formed the participant's endowment was the same pair that was selected in the second round. The participant was continuously presented with both pairs of coins in round two and three; however, when they chose one of the pairs in the second round, it was that choice of pair that became their endowment. The two decisions are related: the decision in the second round may have influenced the third round.

For both decisions, a participant should have been indifferent between the two pairs as they are of equal value. If a participant was offered the choice between two equally valued pairs multiple times, they should have tended to select one pair 50% of the time and the other pair 50% of the time. If they selected one pair more often than the other, then the participant valued that pair more than the other. If they favoured the pair that formed their endowment, the pair that they chose, then this provides evidence of an Endowment Effect. By analysing the decision in the third round, I can observe which of the two pairs (the endowment or the other) the participant preferred (if any) and confirm this through a T-test[3] (Satterthwaite, 1946). Furthermore, by analysing the second round, I can use a T-Test to test whether a participant preferred one of the two coin types (please see 'The Control' in Section 7: Discussion). A T-test was run on the observations to test whether a participant was equally likely to select either pair. To differentiate between the two pairs in the third round, I used a dummy variable, called Var1, to indicate whether the pair was the endowment or not. If a participant selected a pair in round three and it was the same pair that they selected in round two, a

[3] Satterthwaite, F. E. 1946. *An approximate distribution of estimates of variance components*. Biometrics Bulletin 2: 110-114 and Welch, B. L. 1947. The generalization of `student's' problem when several different population variances are involved. Biometrika 34: 28-35

value of one was assigned to Var1. If the participant selected a different pair in round three to the one they selected in round two, a value of zero was assigned to Var1. In other words, if the participant selected their endowment in the third round, a value of one was assigned and if the participant did not, a value of zero was assigned to Var1. If there was no Endowment Effect, a participant would have been indifferent between the two pairs in the third round. This means that the average of Var1 across all rounds would have been 0.5, since the participant would have tended to select their endowment half of the time and the other pair, half of the time:

This average was the null hypothesis for the T-test:

The mean of Var1 should be equal to 0.5

Or

H0: meanVar1 = 0.5

Any divergence from an average of 0.5 for Var1 meant that one pair was preferred over the other. If the mean was greater than 0.5 it means that the endowment was preferred to the other pair. If that did occur, there was evidence of an Endowment Effect, since there was no reason for this to occur in the absence of the Endowment Effect, *ceteris paribus*.

In total, three T-tests were run with the null hypothesis of meanVar1 = 0.5. Two tests were run on each version of the game respectively, to test for evidence of an Endowment Effect in both the presence and absence of a transaction cost and one was run across all observations regardless of the version.

An additional T-test was also conducted on the data to determine whether the addition of the added transaction cost in version two of the game led to a change in the results. Here, the null hypothesis was:

The difference between the mean of Var1 for version one of the game is equal to the mean of Var1 for the second version of the game

Or

H0: diff = 0; where diff = meanVar1 (1) – meanVar2 (2)

If the null hypothesis was rejected, i.e. that there is no difference between the means, then there was an effect from the transaction costs as the two means between the two versions are statistically different.

The results from these four T-tests are presented and discussed below.

6. Results

6.1. Results

The experiment was used to test whether there is evidence of an Endowment Effect. It did so by analysing whether there is no evidence of an Endowment Effect (H_0) and testing this against the alternative that there is (H_1). The experiment was also designed to analyse the impact of transaction costs on this effect (do transaction costs reinforce or diminish the null or alternative hypotheses). The experiment was also designed to address the concerns in the literature, that found no evidence of an Endowment Effect when these concerns were addressed (supporting H_0). Below, in table 1, I present the findings of the experiment which shows statistically significant evidence that participants had a bias towards choosing their initially chosen bundle in both versions of the experiment. This supports the alternative hypothesis (H_1). The average for both versions, both separately and combined, is above 0.5. In the absence of any Endowment Effect, participants should have had an average of 0.5; they should have been equally likely to select either pair in round three. The average for all tests being greater than 0.5 provides evidence of the Endowment Effect as participants were more likely to select, in the third round, the pair they were endowed with in the second.

Table 1: Summary of the Results (please see Appendix A6 for the full result tables)

	Observations	Mean	H_1: mean ≠ 0.5	H_1: mean < 0.5	H_1: mean > 0.5
1) All	490	0.77	0.0000	1.0000	0.0000
2) Version One	249	0.73	0.0000	1.0000	0.0000
3) Version Two	241	0.83	0.0000	1.0000	0.0000

In table 2 below, I present the results of the experiment which shows that there is a statistically significant evidence that transaction costs reinforce the bias observed in version one of

the game (transaction costs reinforce H_1). In the below table, the means of the two versions were compared and the difference between them tested for statistical significance. In the absence of any transaction cost effect, the difference between the means should be zero. In table 2 below, the null hypothesis that the difference between the means is equal to zero can be rejected at the 5% and 10% significance level (p-value of 0.0116) in favour of the null hypothesis that the two means are different.

Table 2: Summary of the Results (please see Appendix A6 for the full result tables)

	Observations	Mean	H_1: $mean_{version1}$ - $mean_{version2} \neq 0$	H_1: $mean_{version1}$ - $mean_{version2} < 0$	H_1: $mean_{version1}$ - $mean_{version2} > 0$
4) Comparison of Means	490	-0.095	0.0116	0.0058	0.9942

6.2. Descriptive Analysis

Demographic information (gender, age, and education) on each participant was captured using a questionnaire. This demographic data is used to examine whether the Endowment Effect holds within each demographic group and whether there are differences in the magnitude of the effect between groups (is one group more likely to exhibit the endowment effect than another).

The data is divided into two samples: data for version one and data for version two of the game. The data is further subdivided into three categories: gender, age and education level. For gender, data is split between two groups: male and female. For age, observations are divided between four age groups: participants between the age of 18 and 21 inclusive, participants between the age of 22 and 25 inclusive, participant between the age of 26 and 29 inclusive and participants aged 30 and older. Data is divided into four groups based on participants' education level: participants in the

process of obtaining a bachelor degree, participants who hold a bachelor degree, participants who hold an honours degree and participants who hold a master's degree. Three tables containing descriptive statistics based on these groupings, are presented below.

Table 3: Means

	Version 1		Version 2	
	Observations	Mean	Observations	Mean
1) Gender				
- Female	122	0.72***	98	0.85***
- Male	127	0.74***	143	0.81***
2) Age				
- 18 to 21	40	0.65*	41	0.73***
- 22 to 25	119	0.74***	102	0.83***
- 26 to 29	43	0.81***	50	0.82***
- 30+	47	0.70***	48	0.9***
2) Education				
- Obtaining Bachelor	23	0.78***	24	1#
- Hold Bachelor	94	0.68***	83	0.71***
- Hold Honours	120	0.78***	116	0.87***
- Hold Masters	12	0.5	18	0.83***

Null hypothesis: $H_0 = 0.5$. *** Significant at 1% level; * Significant at 10% level. # P-value not available.

The data in table 3 reflects whether there is evidence of an Endowment Effect within each demographic grouping. The null hypothesis states the mean is equal to 0.5; any statistically significant result indicates that the null hypothesis can be rejected in favour of the alternative that an Endowment Effect exists.

There is evidence of an Endowment effect in both male and female participants for both versions as the mean is statistically significant at the 1% level. The endowment effect is exhibited in both male and female participants.

There is evidence of an endowment effect within all age groups for both versions at the 10% significance level. However, for participants between the age of 18 and 21, the null hypothesis cannot be rejected at the 1% and 5% level. This indicates that there may be no, or limited evidence of an Endowment effect for this age group in version 1 of the game.

There is evidence of an endowment effect at the 1% significance level for all education groups across both versions of the game except for participants who hold a master's degree playing version one of the game. The null hypothesis cannot be rejected at the 1%, 5% or 10% significance level and the average equals 0.5 suggesting that there is no endowment effect for this group.

The results indicate that the Endowment Effect occurs in all demographic groupings across both versions of the game except for two groupings from version one of the game: participants who hold a master's degree and those aged between 18 and 21. The effect is strengthened between version one and version two across all demographic groups. Table 3 above examines whether there is an endowment effect within each group, the two tables that follow analyse whether there is a difference between groups.

To test this, the following set of specifications is used across demographic groups:

(1) $var1 = \gamma + \beta_1 Female + \varepsilon_1$

(2) $var1 = \alpha + \beta_2 Age_1 + \beta_3 Age_2 + \beta_4 Age_3 + \varepsilon_2$

(3) $var1 = \delta + \beta_5 Education_1 + \beta_6 Education_2 + \beta_4 Education_3 + \varepsilon_3$

Where:

- γ, α and δ are the respective constants.
- $Female$ is a dummy variable for Gender (1 for female, 0 for male).

- $Age_{1,2,3}$ are the dummy variables for the three non-reference age groups (Age_1 has a value of 1 for participants aged 22 to 25 and 0 for all other age groups; Age_2 has a value of 1 for participants aged 26 to 29 and 0 for all other age groups; Age_3 has a value of 1 for participants aged 30 and older and 0 for all other age groups). The reference group is participants aged 18 to 21.
- $Education_{1,2,3}$ are the dummy variables for the three non-reference education groups. ($Education_1$ has a value of 1 for participants who hold a bachelor degree and 0 for all other education groups; $Education_2$ has a value of 1 for participants who hold an honours degree and 0 for all others; $Education_3$ has a value of 1 for participants who hold a master's degree and 0 for all others). The reference group is participants in the process of obtaining a bachelor degree.
- $\varepsilon_{1,2,3}$ are the respective error terms.

Table 4: Regression results for version one

	(1) var1	(2) var1	(3) var1
Female	-0.02 (-0.33)		
Age_1		0.09 (1.10)	
Age_2		0.16* (1.68)	
Age_3		0.05 (0.55)	
$Education_1$			-0.1 (-0.99)
$Education_2$			0.00 (0.01)
$Education_3$			-0.28* (-1.80)

	(1) var1	(2) var1	(3) var1
Constant (γ, α, δ)	0.74*** (18.74)	0.65*** (9.25)	0.78*** (8.51)

***Significant at 1% level. *Significant at 10% level.

The values for the respective constants in table 4 correspond to the means in Table 3. In addition, the coefficients in table 4 added to the constants also correspond to the means in Table 3. For instance, the mean of var1, in table 4, for participants who are between the ages of 22 and 25 playing version one of the game is $\alpha + \beta_2 = 0.65 + 0.09 = 0.74$. The specifications listed add value to Table 3 by testing for differences in the Endowment Effect between groups. This is done by testing whether the coefficients for the variables are statistically different to 0. If the null hypothesis cannot be rejected, then there is no difference between the averages of var1 between groups.

In table 4, for specification (1), the coefficient on the gender dummy variable, Female, is not statistically significant. There is no difference between male and female and both exhibit an Endowment Effect. For specification (2), all the coefficients are not significant at the 1% and 5% level. The coefficient on Age_2 is significant at the 10% level. The coefficient is also positive, which indicates that the Endowment Effect is stronger for participants aged 25 to 29 than it is for participants aged 18 to 21. Other than this, there is no significant difference between age groups and all exhibit an Endowment Effect. For specification (3), all coefficients are not significant at the 1% and 5% level however, the coefficient on $Education_3$ (those who hold a master's degree) is significant at the 10% level. From the analysis in table 4, the results indicate that the Endowment Effect is present for all education levels except for those who hold a master's degree. Furthermore, the average for those who hold a master's degree is significantly different to the other education levels.

Table 5: Regression results for version two

	(1) var1	(2) var1	(3) var1
Female	0.04 (0.72)		
Age_1		0.10 (1.45)	
Age_2		0.09 (1.11)	
Age_3		0.16** (2.04)	
$Education_1$			-0.29*** (-3.36)
$Educatuon_2$			-0.13 (-1.55)
$Educaiton_3$			-0.17 (-1.44)
Constant (γ, α, δ)	0.81*** (25.49)	0.73*** (12.36)	1*** (13.2)

***Significantly different to zero at 1% level. **Significant at 5% level. *Significant at 10% level.

In table 5, for specification (1), the coefficient on the gender dummy variable, Female, is not significant indicating that there is no difference between genders. Together with the results from table 3 where the average is statistically different to 0.5, there is evidence of an Endowment Effect in both genders. For specification (2), there is no difference between age groups except for those aged 30 and above. Here the null hypothesis can be rejected at the 5% significance level. The magnitude of the coefficient is also positive. The Endowment Effect is present in each age group. The Endowment Effect is not exhibited differently between age groups except for those aged 30 and above who exhibit a stronger effect compared to those aged 18 to 21. For specification (3), there is a difference between those obtaining a bachelor degree and those who hold one at the 5% significance level. The magnitude of the coefficient is also negative indicating that the endowment effect is less

prevalent for those aged 22 to 25 compared to those aged 18 to 21 (the mean of var1 is lower). Together with the information in table 3, there is evidence of an endowment effect in all groups.

Although the data may suffer from sample bias, the results from the descriptive analysis indicate that there is an Endowment Effect present in the majority of demographic groups and there is little difference between the groups. Furthermore, the endowment effect strengthens across all groups when the participants are exposed to an added transaction cost in version two of the game.

7. Discussion

The results provide evidence (i) of an Endowment Effect, and (ii) that transaction costs compound this effect. This provides support for the alternative hypothesis (H_1).

1) There is evidence of an Endowment Effect:

The null hypothesis (H_0) tests whether, in round three, a participant was equally likely to select the pair they were endowed with in round two or select a different pair of equal value in round three. In the absence of any Endowment Effect, a participant should have selected either pair with equal likelihood since they had the same value. The null hypothesis thus tests whether there was no Endowment Effect and a failure to reject the null hypothesis would lead to the conclusion that there is no evidence of any Endowment Effect. The results, in table 2 above, show an average that is greater than 0.5 for both version one, version two and both versions combined. This average is high enough for the null hypothesis to be rejected. Furthermore, the null is rejected in favour of the alternative hypothesis (H_1) that the mean is greater than 0.5. This is evidence that there is an Endowment Effect. A participant was more likely to select, in the third round, the same pair they were endowed with in the second, than they were likely to select the pair that they were not endowed with. The pair the participants were endowed with must be of greater value *to the participants* than the other pair since there is a preference for the endowment. The Endowment Effect causes a participant to value something they own more than an identical alternative and would therefore increase the value of the Endowment. This substantiates the observed behaviour in the experiment.

2) Transaction costs reinforce the Endowment Effect:

The null hypothesis in table 2 that was tested is whether there was no impact from transaction costs. The way it was tested was whether the mean of version one (no transaction cost differential) was equal to the mean of version two (with a transaction cost differential). The difference between the two means is -0.095. The negative value of the difference means that the

mean of version two is greater than that of version one and the mean of version two is further from 0.5 than version one. This provides evidence that the transaction costs reinforce the Endowment Effect since the larger the difference between the mean and 0.5, the more prevalent the Endowment Effect. This is further evidenced by the results in table 2 which finds that the null hypothesis (no transaction cost effect) can be rejected in favour of the alternative hypothesis that the mean of version two is greater than version one (reinforcement of the Endowment Effect) but cannot be rejected in favour of the other alternative hypothesis that the mean of version one is greater than version two (dampening of the Endowment Effect). In summary, the results show that there was a transaction cost effect and it reinforced the Endowment Effect, however the effect was minimal as the results are not statistically significant at the 1% significance level.

The results show that there is an Endowment Effect and this effect is reinforced by Transaction costs, however the predominant effect is the Endowment Effect.

The Control

The experiment also provided a control to assess whether the independent variable (endowing a participant) was solely responsible for the results seen. The second round of the game provided this control. In this round, participants chose between two pairs of equal value but in this case, there was no Endowment Effect as no participants had been endowed with any coins. In the absence of any Endowment Effect, a participant should have been indifferent between either pair and this formed the null hypothesis of the T-test used in the study. By assigning a value of 1 to a pair of heads chosen by participants and a value of 0 to a pair of tails, I ran a T-test with the null of 0.5 (a participant selected heads 50% of the time and conversely, tails 50% of the time).

Table 6: Summary of Results on the Control

	Observations	Mean	H_1: mean ≠ 0.5	H_1: mean < 0.5	H_1: mean > 0.5
1) All	490	0.51	0.5883	0.7059	0.2941
2) Version One	249	0.57	0.0132	0.9934	0.0066
3) Version Two	241	0.44	0.0820	0.0410	0.959

When all the results are used, the results show that there was no preference for either pair, the mean of 0.51 is not statistically different to 0.5 at any standard significance level (see table 6). For version one's results, there was a slight bias towards heads at the 5% significance level. For version two's results, there is a slight bias towards tails at the 10% significance level. This indicates that although there was a preference for a pair of heads in version one and tails in version two, these preferences were small and the null hypothesis that there was no preference cannot be rejected at the 1% significance level.

The second round, the control, was identical to the third round in every respect except one, the third round introduced the independent variable: endowing the participant. As there was no other variable introduced in the third round, the observation that participants selected the same pair in the third round as they did in the second, is attributable to the effect from endowing the participant.

8. Conclusion

This study tested the theory of the Endowment Effect using an experiment designed to address several shortcomings in the literature. The concerns on the topic relate to the sensitivity of the WTA and WTP measures to the type of good and its market setting, the availability of substitutes, and the ability of the measures to capture human preferences. The experiment addressed this by using a measure that was distinct to WTA and WTP, a good that did not rely on a market to determine its value, by having made the goods unique to the setting (to avoid any preference towards either of the two goods) and by controlling for substitutability. This experiment did this, not by allowing participants to offer and accept, but by allowing participants to play a game in which their decisions were recorded. Their decisions were benchmarked against a null hypothesis that was provided by the probabilities of the coins used in the experiment. The null hypothesis (H_0) that was tested, was that there was no Endowment Effect: a participant was equally likely to select either pair in round three.

Furthermore, the experiment examined the effects of transaction costs on the Endowment Effect as it introduced a second version of the game which controlled for any transaction costs. This allowed me to compare the two versions to assess the impact of transaction costs.

The study found that there was evidence of an Endowment Effect and this effect was reinforced by transaction costs. This provided support for the alternative hypothesis (H_1). The game offered participants the choice between two perfectly substitutable pairs of coins in the second round and once again in the third round. In the absence of any Endowment Effect, the decision the participant made in the second round should have had no influence on the third round. The participant should have been indifferent between the pairs in both rounds and their behaviour should have reflected this as they would have randomly chosen between the pairs. This random selection would've meant that, on average, participants would have selected either pair with equal likelihood. In the presence of an Endowment Effect, participants should have once again been indifferent

between pairs in the second round and should have selected either pair with equal likelihood. The results support this: participants selected either pair with equal likelihood at the 1% significance level, in round two. However, once a participant selected a pair, that pair formed their endowment going into the following round. Since the pair formed their endowed choice from a previous round, the participant was less likely to give up that pair. The participant was attached to and endowed with the choice in round two, not the actual coins. The reason being that the theory of the Endowment Effect suggests that the perceived value of the participants previously endowed pair is higher. This was seen in the third round where participants were given a choice between two equally valued pairs: the pair which they selected and became endowed with previously and the second pair. Relatively speaking, the perceived value of their previous endowment was higher than the perceived value of the other pair and the participant selected their previously endowed type more often than the other pair.

In conclusion, this paper presents evidence of the existence of an Endowment Effect in a manner which is distinct to previous measures employed to test it. It also provides evidence of an Endowment Effect in both the presence and absence of transaction costs where such transaction costs reinforce the Endowment Effect. This not only addresses the concerns of previous studies on the topic but adds to the robustness of the alternative hypothesis that evidence of the of the Endowment Effect can be found.

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Appendix

A1. Experiment Instructions

1. The experiment was conducted during several (computer) laboratory sessions.
2. Each participant presented their student card and was randomly assigned to a computer.
3. Participants were presented with the participation letter, a consent letter as well as a letter explaining how they could access the windows application.
4. Participants accessed the windows application.
5. To begin the application, the participant entered the number corresponding to their computer.
6. They were then presented with the game itself:
    a. The first part explained the rules of the game and what the aim of the game was.
        i. In the game, they were given four coins and were given three rounds to flip them.
        ii. After each round, they could choose to keep aside any number of coins and flip the remainder.
        iii. Each side of the coin was identified by Heads and Tails.
        iv. The aim of the game was to obtain four-of-a-kind (HHHH or TTTT).
        v. The coins or coin that the participant chose was recorded for each flip for all 50 attempts (25 attempts in each version) and stored in a database.
        vi. Participants had 25 attempts per version at playing the game and the game was won once they reached four-of-a-kind. They were awarded R1 every time they won a game.
    b. They then played version one of the game:
        i. To overcome the possible effects of transaction costs and to test whether the Endowment Effect was displayed in the absence of transaction costs, participants were exposed to a version of the game where any coins they

selected and excluded from future tosses were automatically unselected after each flip and were not flipped again by default unless they were reselected.

ii. Thus, the transaction cost of choosing to keep the endowed pair or the other pair was the same, and so transaction costs were controlled for (there was no transaction cost differential).

c. They then played version two of the game:

i. In version two of the game there was an added transaction cost (i.e. to select different coins after the second flip, the participant needed to deselect the coins chosen after the first flip).

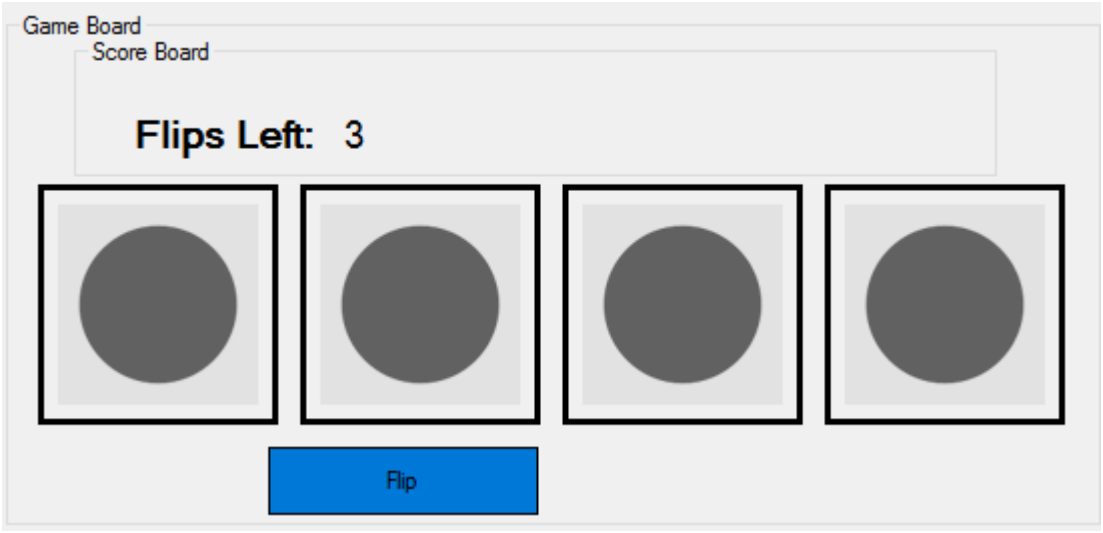
d. The paper then assessed whether the choices between which coins to keep and which coins to flip was done in a meaningful way and this was used to determine whether there is or isn't evidence of the Endowment Effect.

7. The experiment was then concluded.

A2. How the Game was Played?

Step 1: The game loaded and a participant saw four greyed-out coins on the screen (Figure 11).

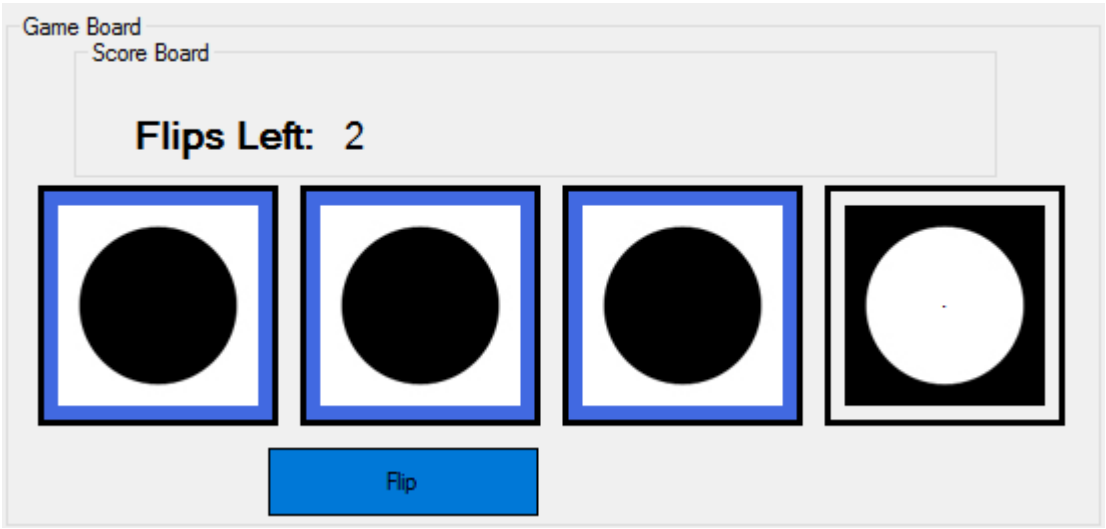
Figure 11: Round One, welcome screen to the game



The participant was unable to select any coins until they clicked on the blue 'Flip' button. This was the participant's first round[4].

Step 2: After clicking on the 'Flip' button the participant was presented with the following bundle of coins. The participant had not achieved the four-of-a-kind bundle needed to win. A participant therefore selected which coins to keep aside and which coins to flip (Figure 12).

Figure 12: Round Two, selected coins highlighted in blue

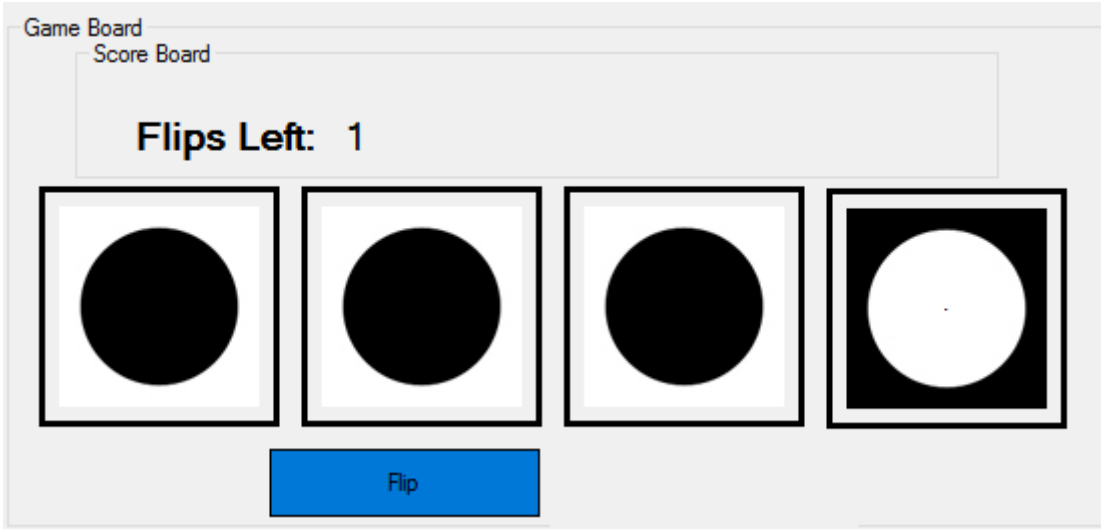


The coins that were highlighted in blue (see figure 12), are the coins that the participant selected to keep aside. In this case, the participant selected the three head (●) coins. This means that only one coin was flipped in the next round, the tail (○) coin.

Step 3: The participant once again clicked on the blue 'Flip' button. After clicking on the 'Flip' button the participant was presented with the following coin bundle (figure 13).

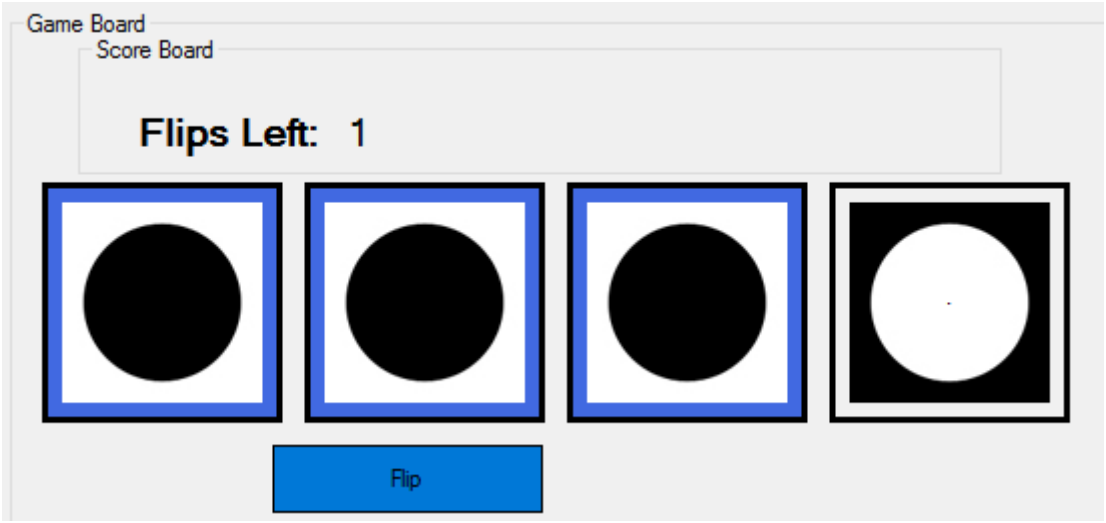
[4] Each of three rounds ends with a flip. Round one is concluded by the first flip. A flip is the actual action of flipping the coins whereas a round includes the decision of which coins to select before each flip.

Figure 13: Round Three, prior to any selection



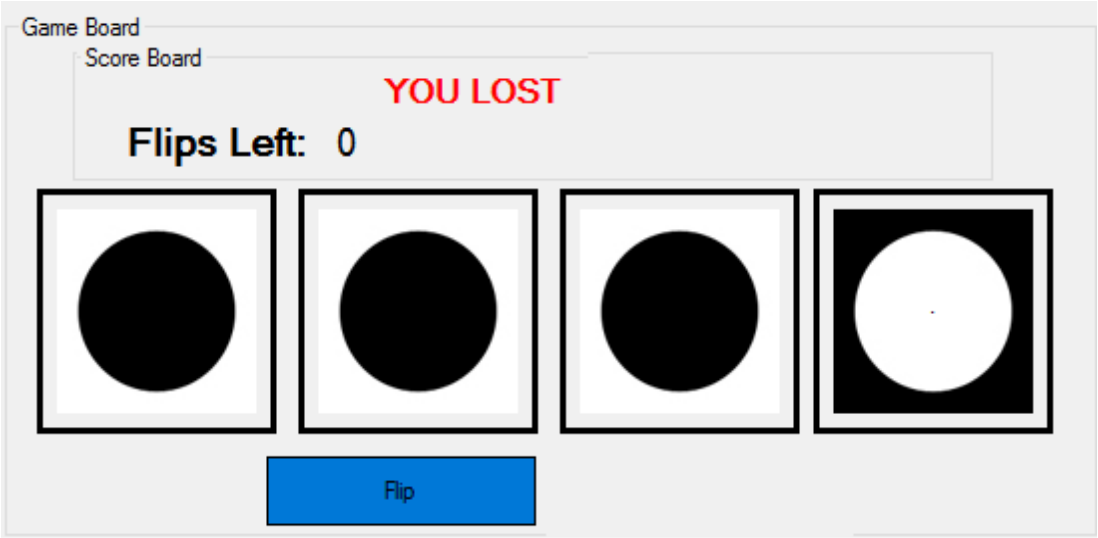
Once again, the participant had not achieved the required four-of-a-kind bundle required to win. At this point the participant had completed two attempts at flipping the coins and had one flip remaining. As figure 13 shows, the three coins (heads) that were kept aside were not flipped. However, the fourth coin, the tail, was flipped, and once again landed on a tail. Before the third and final flip the participant had the chance to change their selection. The participant is assumed to have selected the coin type that appeared the most in the round, i.e. the three heads. The three coins that are selected are highlighted in blue in Figure 14 below.

Figure 14: Round Three, selected coins highlighted in blue



Step 4: The participant then clicked on ‘Flip’. This was their last remaining flip. The final flip concluded the third and final round and the participant was presented with one final bundle of coins. The game ended at this point regardless of whether the participant had obtained four-of-a-kind or not. In this example the participant was presented with the following bundle (figure 15).

Figure 15: End of the Game



The participant had no flips remaining and did not achieve four-of-a-kind and so the participant lost the game.

A3. Value of Each Coin

The participant made decisions between bundles. When a participant kept aside coins of the same type, the participant was choosing between bundles of coins. There were only three types of bundles that a participant had during each round:

1. Bundle type A: Three coins of any one coin type (three-of-a-kind) and one coin of the other coin type (one-of-a-kind).
2. Bundle type B: Two coins of each coin type (two pairs).
3. Bundle type C: Four of any one coin type (four-of-a-kind).

Each bundle had a value which was determined by the probabilities of the game. The more likely a given bundle helped a participant achieve "four-of-a-kind" the more valuable that bundle was. If a participant was awarded 1 point every time a participant won the game, it was easy to determine the value of each bundle in terms of win probability. The bundle's value was determined by the likelihood that the coins excluded from that bundle will land with the same type as the coins kept aside. The probabilities are displayed in table 7 below:

Table 7: Value of each Bundle

	Example 1	Example 2	Description	Value
Bundle A	HHHT	TTTH	Bundle A required that the single coin (T in Example 1 or H in Example 2) was flipped and landed on the same type as the other three coins; achieving "four-of-a-kind".	50% Chance that the single coin would land on the required type. Value = 0.5
Bundle B	HHTT		Bundle B required that one of the pairs was flipped and both coins landed on the same type as the pair excluded from the flip.	25% Chance Value = 0.25
Bundle C	HHHH	TTTT	The game was won	Value = 1

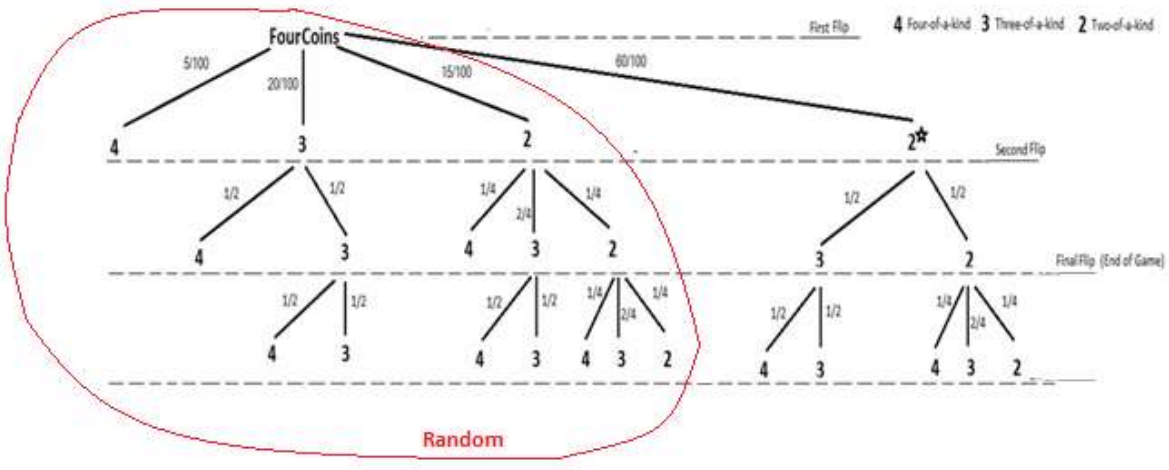
As each coin was a fair two-sided coin, there was a 50% chance a single coin would land on either side. As each coin in a single flip was independent of one another, this 50% probability was multiplied by the number of coins being flipped:

$$(0.5)^n = Pr; where\ n = the\ number\ of\ coins.$$

In bundle A, the three-of-a-kind (the three heads in example 1 and the three tails in example 2 in table 7) was more valuable than the single one-of-a-kind coin (the tail and head in example 1 and 2 respectively in table 7) since three-of-a-kind had a 50% chance of leading to four-of-a-kind in the next round whereas the one-of-a-kind only had a 12,5% chance of leading to four-of-a-kind in the next round. Since the decision between which bundles (three-of-a-kind vs. one-of-a-kind) was not a decision between perfect substitutes, this bundle is excluded from the analysis. For Bundle C, there was no decision to be made and so this is excluded from the analysis. This leaves Bundle B: Bundle B consisted of two pairs, both equally likely to have led to "four-of-a-kind" in the next round (25%). Each pair is bundle B were thus perfect substitutes and the participant should have been indifferent between them. As they were perfect substitutes, I could endow a participant with one pair in the second round and then make them choose between that endowment and another pair in the third round, which provided the basis for observing an Endowment Effect.

A4. The Game's Weighting

Figure 16: The Game's Weighting



Furthermore, the game was weighted (see figure 16) to increase the likelihood of a participant obtaining two pairs in each round. The game was weighted as follows: the game was random 40% of

the time and for the other 60%, the gaming engine ensured the participant received two pairs in the second round (see 2* in figure 16). This was done so that the number of useable observations increased: 75% of flips in the second round resulted in a participant being presented with two pairs. In total, there was a 33.75% chance of a participant obtaining two pairs after the first flip and obtaining two pairs again after the second flip (in the third round). The probability of this situation occurring if the game was purely random would only be 9.38%.

A5. Data

A5.1. Data Captured

Data was obtained through the participants' participation in the game. 31 individuals participated in the experiment. Each participant was assigned a unique ID which was recorded, along with the version of the game the participant played, the game number (1-25; per version) as well as all the decisions they made in each three-flip game. A sample is shown below:

Table 8: Sample of the captured data

Respondent ID	Version	Game #	Coins on Offer 1	Coins Selected 1	Coins on Offer 2	Coins Selected 2	Coins on Offer 3	Win/Lose
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
11	1	1	H,T,T,H	T,T	T,T,T,H		T,H,H,H	LOSE
11	1	2	T,T,H,H	H,H	T,T,H,H	T,T	T,T,T,H	LOSE

In table 8, the participant was assigned an ID of 11. This ID corresponds to all the decisions that the individual made during the game. Each row corresponds to a three-round game. Looking at the first row, one can see:

- The result is from version one of the game (see: Column 2).
- It was the first of 25 games that the participant played (see: Column 3)
- After the first flip, a participant was presented with H, T, T, H (two pairs) (see: Column 3).
- The participant selected T,T (one of the two pairs) (see: Column 5).

- The participant then flipped the two other coins and was presented with T, T, T, H (three tails and a single head) (see: Column 6).
- The participant did not select any coins (see: Column 7).
- The participant then flipped all four coins and was presented with H, H, H, T (see: Column 8).
- As there are no more flips remaining, the participant did not win (i.e. they had not obtained four of any one type).

A5.2. Data Filter

Here I filtered out all the results that did not pertain to the Endowment Effect. This left only the results in which a participant chose between two pairs after the first flip and two pairs after the second flip. Taking the same extract from above, one can see how this was done in table 9:

Table 9: Sample of the captured data after filtering results

Respondent ID	Version	Game #	Coins on Offer 1	Coins Selected 1	Coins on Offer 2	Coins Selected 2	Coins on Offer 3	Win/Lose
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
~~11~~	~~1~~	~~1~~	~~H,T,T,H~~	~~T,T~~	~~T,T,T,H~~		~~T,H,H,H~~	~~LOSE~~
11	1	2	T,T,H,H	H,H	T,T,H,H	T,T	T,T,T,H	LOSE

This left only the second row.

A5.3. Data Transformation

Once the data had been filtered leaving only the relevant observations, it needed to be converted into a variable that could be tested. This was done, by creating a dummy variable, using an *IF Function* on excel:

=IF(*COL5*=COL7,1,0)

[If the value contained within column 5 is the same as the value contained within column 7, then assign this cell a value of 1. If the value is not the same, assign a value of 0.]

In table 10, Column 5 and 7 are populated with a series of pairs, either H,H or T,T. If column 5 contained the same pair as column 7, a value of 1 was assigned and if it did not, then a value of 0 was assigned. The reason for this dummy variable follows on from the methodology: if an individual selected the same pair in the third round (as they did in the second), the value is 1 and if they selected a different pair the value is 0. In the absence of any Endowment Effect (or transaction cost) one would have expected that on average, an individual selected the same pair half the time and changed pairs half the time. By equating each to a value of 1 and 0 respectively, one can create a probability distribution function with a normal distribution. In this case, the average *should* be equal to 0.5 (see table 10).

Table 10: Sample of Transformed Data (Var1)

Respondent ID	Version	Flip 1	Coins on Offer 1	Coins Selected 1	Coins on Offer 2	Coins Selected 2	Coins on Offer 3	Win/Lose	Var1
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
11	1	2	T,T,H,H	H,H	T,T,H,H	T,T	T,T,T,H	LOSE	0
11	1	12	H,T,T,H	T,T	H,T,T,H	T,T	T,T,T,H	LOSE	1
11	1	14	H,H,T,T	H,H	H,H,T,T	T,T	T,T,T,T	WIN	0
11	1	17	H,T,T,H	T,T	H,T,T,H	T,T	T,T,T,H	LOSE	1
								Average	0.5

A6. Results

Table 11: T-test (Null Hypothesis of a mean of 0.5) on all observations

```
One-sample t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    var1 |     490    .777551    .0188072    .4163162    .740598    .814504
------------------------------------------------------------------------------
    mean = mean(var1)                                             t =  14.7577
Ho: mean = 0.5                                  degrees of freedom =      489

   Ha: mean < 0.5               Ha: mean != 0.5                 Ha: mean > 0.5
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

In table 11, the T-test was run across all 490 observations. The mean of the var1 for all observations is **0.78.** The p-value of 0.0000 suggests that the null hypothesis can be rejected at the 1%, 5% and 10% significance levels in favour of the alternative that the mean of var1 is statistically different to 0.5. Furthermore, the null hypothesis can be rejected in favour of the alternate hypothesis that the mean of var1 is greater than the predicted mean of 0.5 (p-value of 0.000); again, this is significant at the 1%, 5% and 10% significance levels. The null hypothesis cannot be rejected in favour of the alternative hypothesis that the mean of var1 is less than 0.5 (p -value of 1). Although these results do suggest that there is evidence of an Endowment Effect, it does not control for the effect from the additional transaction cost in the second version of the game.

Table 12: T-test (Null Hypothesis of a mean of 0.5) on version one of the game

One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
var1	249	.7309237	.028161	.4443729	.6754585	.7863889

mean = mean(var1) t = 8.2001
Ho: mean = 0.5 degrees of freedom = 248

Ha: mean < 0.5 Pr(T < t) = 1.0000
Ha: mean != 0.5 Pr(|T| > |t|) = 0.0000
Ha: mean > 0.5 Pr(T > t) = 0.0000

To control for the transaction costs, a T-test was only run on the first version of the game; the results of which are presented in table 12. The null hypothesis tested here is that the average of var1 is equal to 0.5 (there was no Endowment Effect). There are 249 observations in this first version of the game. The average of var1 across all 249 observations is **0.73**. The null hypothesis that the mean of **0.73** is equal to 0.5 can be rejected at the 1%, 5% and 10% significance levels (p-value of 0.0000) in favour of the alternative hypothesis that the mean of var1 is different to 0.5. The null hypothesis that the mean of var1 is equal to 0.5 can also be rejected in favour of the alternative hypothesis of that the mean is statistically greater than 0.5 at the 1%, 5% and 10% significance levels (p-value of 0.0000). The null hypothesis cannot be rejected at any significance level in favour of the alternative

hypothesis that the mean is lower than 0.5. The results suggest that in the mean is not only statistically different to 0.5 but it is also statistically greater than 0.5. Although discussed in section 7 in more detail, this suggests that individuals' behaviour was not random and there may have been some other effect (hypothesised by this paper to be the Endowment Effect).

Table 13: T-test (Null Hypothesis of a mean of 0.5) on version two of the game

```
One-sample t test
```

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
var1	241	.8257261	.0244866	.3801343	.77749	.8739622

```
    mean = mean(var1)                                         t =  13.3022
Ho: mean = 0.5                                 degrees of freedom =      240

   Ha: mean < 0.5               Ha: mean != 0.5                 Ha: mean > 0.5
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

The Endowment Effect is a counter-argument to the idea presented by the Coase Theorem that initial endowments do not matter in the absence of transaction costs (Tversky & Kahneman, 1991). This paper then controls for transaction costs and analyses their effects by including a second version of the game which adds an additional transaction cost which is not present in the first version. A T-test was run on the second version to evaluate the effects of this transaction cost. The results are presented above in table 13. The mean of the 241 observations is **0.82** which is higher than the mean in table 12. The null hypothesis can be rejected at the 1%, 5% and 10% significance levels (p-value of 0.0000) in favour of the alternative hypothesis that the mean is not equal to 0.5. The null hypothesis can also be rejected in favour of the alternative hypothesis that the mean is greater than 0.5 (p-value of 0.0000). The null hypothesis cannot be rejected in favour of the alternative hypothesis that the mean is less than 0.5 (p-value of 1). The higher mean for the observations in the second version (as compared with the first) suggests that transaction cost did influence the behaviour of participants, however it is important to see whether this difference between the two means is statistically significant.

Table 14: Test to determine differences between the two versions of the game

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
1	249	.7309237	.028161	.4443729	.6754585	.7863889
2	241	.8257261	.0244866	.3801343	.77749	.8739622
combined	490	.777551	.0188072	.4163162	.740598	.814504
diff		-.0948024	.0374127		-.1683123	-.0212926

diff = mean(1) - mean(2) t = -2.5340
Ho: diff = 0 degrees of freedom = 488

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.0058 Pr(|T| > |t|) = 0.0116 Pr(T > t) = 0.9942

In this test (see table 14), the difference between the two means is compared using a two-sample T-test. Here the null hypothesis is that the mean of group 1 (first version of the game) and the mean of group two (second version of the game) are equal. In other words, is the difference between the two means statistically equal to zero? The difference between the two means is **-0.095.** It is negative as the second mean is higher than the first. The null hypothesis that there is no difference between the means is statistically significant at the 5% and 10% level but not at the 1% level (p-value of 0.0116). This means that there is some affect from the transaction cost (which increases the mean of var1 away from 0.5) but it is small and it is negligible at the 1% significance level.