Mathematics self-confidence and the "prepayment effect" in riskless choices*

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September 20, 2016

Abstract

We extend the analysis of a riskless choice experiment reported recently by Hochman et al. (2014). Participants select from among sets of standard playing cards valued by a simple formula. In some sessions, participants are given a prepayment associated with some of the cards, which need not be the earnings-maximizing ones. Hochman et al. find that participants choose an earnings-maximizing card less frequently when another card is prepaid. We replicate this result under the original instructions, but not with instructions which explain the payment process more explicitly. Participants who state they do not consider themselves good at mathematics make earnings-maximizing choices much less frequently. Prior experience with economics experiments in general improves performance only modestly. The results suggest that even when comparisons among choices require only simple quantitative reasoning steps, market designers and regulators may need to pay close attention to how the terms of offers are expressed, explained, and implemented.

JEL Classifications: C91; D83

Keywords: loss aversion; prepayment; replication; mathematics self-confidence; lab rats.

*We thank Guy Hochman for sharing the data from the original experiment, and Piers Fleming, Robert Sugden, and seminar participants at University of East Anglia for comments and suggestions, as well as the helpful comments of two anonymous referees and the associate editor. Turocy acknowledges the support of the Network for Integrated Behavioural Science (Economic and Social Research Council Grant ES/K002201/1). All errors are the sole responsibility of the authors.

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1 Introduction

A stylized fact of behavioural economics is that individuals dislike losses more than they like equivalent gains. The endowment effect (e.g. Thaler, 1980; Kahneman et al., 1990), status quo bias (e.g. Kahneman et al., 1991), and the sunk cost fallacy (e.g. Thaler, 1999) are well-established behavioral regularities which can be attributed to loss aversion. Some studies of these effects involve cross-modal comparisons involving different types of goods or assets. For example, Kahneman et al. (1990) observed that participants were reluctant to sell a mug given to them by the experimenter at the beginning of the experiment. Evidence is mixed on whether the endowment effect extends to money, as opposed to other goods.[1] Becker et al. (1974) found that participants in a non-incentivized experiment systematically treated outlay costs differently from opportunity costs. However, Kahneman et al. did not find evidence of the effect when they used tokens instead of mugs.

Hochman et al. (2014) (henceforth HAA) report an experiment in which participants perform a series of choice tasks with no objective risk. In each task, participants are presented with a set of four standard playing cards, from which they must choose one. To each card is attached a monetary value, which depends on both the suit and the rank of the card. In one treatment, participants receive an advance payment, which corresponds to a specific pattern of choices across five out of seven decision tasks. Some of these choices are not the optimal (earnings-maximizing) ones for their corresponding task. In a control treatment, participants receive no advance payment. They find that participants who receive prepayment are more likely to carry out the pre-paid choice even when it is not earnings-maximizing, while participants who do not receive prepayment are relatively more likely to make the earnings-maximizing choice. As the choice task involves no objective risk, HAA interpret this result as supporting loss aversion in money in a very strong form, and label this the "prepayment effect."

Such a strong result could have significant implications for the choice architectures firms use to interact with employees, contractors, and consumers. HAA give an example in which a firm pre-pays its downstream agents their commissions for selling their product, with the requirement that those agents pay back commissions should they fall short of their target; the prepayment effect would suggest these agents are more likely to stick with selling the firm's product (as opposed to a rival's) when they are paid in advance. The phenomenon of sticking to an apparently suboptimal decision has a parallel in consumer decision-making, in which it is argued that consumers fail to switch suppliers in markets such as banking, energy, and telecommunications, even though better plans are on offer. (Wilson and Waddams-Price, 2010; Lunn, 2011; Grubb, 2015; Grubb and Osborne, 2015; Sitzia et al., 2015) In those markets, complexity has been cited as one driver of

[1] For a lengthier discussion see Hochman et al. (2014).

stickiness in both empirical and laboratory studies. (Larrick and Soll, 2008; Allcott, 2011; Kalayci and Potters, 2011; Sitzia and Zizzo, 2011; Grubb and Osborne, 2015)

The only complexity consideration in HAA's task is the dependence of the value of the card on its suit. Spades are worth USD 0.25 times the rank of the card, while all other suits are worth USD 0.10 times the rank of the card. The values of the cards are thus not determined by a single, common standard (Gaudeul and Sugden, 2012; Piccione and Spiegler, 2012) but depend on two dimensions, suit and rank. In two of the three conditions reported by HAA, participants are provided with the monetary value of the cards, either instead of or in addition to the card's suit and rank. In those conditions, in which the values of the cards have been in effect reduced to a common standard, HAA do not observe a prepayment effect. HAA's experiment demonstrates that the introduction of a minimally non-common standard can be enough to affect decision-making significantly.

In this paper, we take a closer look at HAA's card-choice task to understand more completely the drivers of the prepayment effect. In Section 2, we conduct an analysis of the experimental design, focusing on their "distant representation" treatment in which values of cards are not presented using a common standard. Based on previous literature, we identify a number of candidate factors which might affect a participant's propensity to choose a card which does not maximize their earnings. These include features of the choice architecture – specifically, the content and structure of the experimental instructions – as well as demographic factors including the participant's prior experience in experiments and their self-perception of their ability in mathematics.

Our results in Section 3 show that behavior in this simple task depends on these factors. First, we replicate the prepayment effect reported by HAA using their experimental protocol and instructions; prepayment can indeed lower the frequency of the earnings-maximizing choice. We show there are significant and substantial differences in the probability of earnings maximization as a function of individual characteristics. Participants who report they are good at mathematics maximize far more often than those who do not, while those who are having their first experience in an economics experiment are slightly less likely to maximize. We also find that the prepayment effect largely disappears under rewritten instructions which describe the transactions that will take place should the participant choose a card other than the one for which prepayment was made. We conclude in Section 4 by discussing how the results from this simple task, which turn out to be quite rich and interesting, might inform the applicability of the prepayment effect beyond the laboratory.

2 Experimental analysis and design

Our experiment replicates and extends the "distant representation" condition of Experiment 1A in HAA. There are seven decision tasks. In each task, a participant sees a set of four playing cards, from which one must be chosen. Each card's monetary value depends both on its suit and its rank. For cards which are spades, the value of the card is GBP 0.25 times the rank of the card. There are 5 spades cards in the deck, from ace to five. For all other suits, the value is GBP 0.10 times the rank of the card. Aces have rank one, so the ace of spades is worth GBP 0.25 and other aces are worth GBP 0.10. The ranks of jacks, queens, and kings are 11, 12, and 13, respectively. In HAA spades are valued at USD 0.25 per rank and other suits at USD 0.10 per rank; our stakes were 50 to 60 percent higher than HAA as measured by using the prevailing exchange rate at the time of the experiment.

The seven sets of cards, which are provided in Appendix C, are presented in the same order for each participant. In two sets, a spade is the earnings-maximizing card; these are called "high-spades" trials. In two other sets, a spade is present, but there is some other non-spade card in the set which is worth strictly more; these are called "low-spades" trials. HAA call the remaining three sets filler trials: of these, one set has a spade and a non-spade card which are tied as earnings-maximizing cards, and the remaining two sets do not contain any spade cards. Participants make their choices for all seven sets of cards without any feedback; a summary screen appears at the end of the session reporting the seven chosen cards, and calculating the participant's earnings for the session.[2]

The experiments were conducted in the laboratory of the Centre for Behavioural and Experimental Social Science (CBESS) at the University of East Anglia. Participants were recruited from the lab's standard subject pool, which is managed using the hRoot system (Bock et al., 2012). The choice task was computerized using zTree (Fischbacher, 2007). Sessions took place between November 2014 and October 2015, and lasted around 20 to 30 minutes, including all instructions and final payment.

2.1 Baseline and replication

Our first objective is to replicate the existence of the prepayment effect within the subject pool at our laboratory. We conduct two treatments, **Post** and **Pre+Amount**, which replicate the two payment conditions used by HAA.[3] For these treatments, we used instructions which deviated as little as possible from HAA's, allowing only for the different currency. Treatment **Post** is a

[2] See Appendix B for screenshots of the decision interface.

[3] We present treatment names in boldface type, choosing names intended to help recall the purpose of each treatment.

standard post-payment setup: participants make all seven choices, then see a summary screen which recaps the decisions and tabulates their earnings. They are then dismissed one-by-one to the payment station and receive their payments in private before departing the laboratory. Treatment **Pre+Amount** implements HAA's prepayment treatment. Each participant is given GBP 3.75 in cash at their station prior to making their choices. Participants are told this amount is the sum value of the five spades cards which will appear among the seven sets (hence the "Amount" in the treatment's label). After all seven choices are made, the summary screen appears; this screen tabulates separately the values of the cards chosen, as well as the value of any spade cards not chosen. Participants are then dismissed one-by-one to the payment station to settle payments in private. We carefully kept to the prepayment framing, in that, for any spades not chosen, we took back coins from the participant, and then gave them different coins for the cards actually chosen; that is, we did not integrate the two payments into a net payment.[4]

Hypothesis 1. *Participants will choose the earnings-maximizing card more often in* ***Post*** *than* ***Pre+Amount****, replicating the existence of the prepayment effect.*

2.2 Influence of the choice environment

HAA attribute the treatment effect they observe between **Post** and **Pre+Amount** to the existence of the prepayment in **Pre+Amount**. We identify two other ways in which the description of the experimental task differs between the two treatments. Exploring alternative instructions serves to map out the robustness of the treatment effect in the lab, but also provides a link to possible applicability in markets. The description of the experimental task is the parallel of the contract between firm and downstream sales agents in HAA's example, or the terms of a tariff in a consumer's plan for electricity, gas, or telecommunications.

In **Pre+Amount**, in order to explain the significance of the GBP 3.75 received in advance of decisions, the instructions included the following language:

> We have placed the cards ace through five of spades in the deck randomly ... The value of the five spades (ace through five) equals a total of three pounds and seventy-five cents: one plus two plus three plus four plus five is fifteen times 25p i.e. three pounds and seventy five pence. We will give you this amount up front.

No parallel language exists in **Post**; the total value of spades is not pointed out to participants explicitly. To identify whether the mere mention of the value of spades might call attention to spades, or otherwise create a reference point, we conduct treatment **Post+Amount**, in which we retain postpayment, but include the language mentioning the total value of spades.

[4] As all decisions were made by this point in the session, this bit of theatre could not affect results; nevertheless we wanted to be careful to maintain the framing throughout the session.

Hypothesis 2. *Participants will maximize less frequently in **Post+Amount** than in **Post**; mentioning the value of spades will result in fewer maximizing choices.*

A second difference between **Post** and **Pre+Amount** is the length and complexity of the instructions. Describing the prepayment protocol necessarily makes instructions longer, as there are more steps to explain to participants.

To check on the robustness of the prepayment effect to alternate but in-principle equivalent ways of explaining the mechanism, we replace some of the text from the HAA originals. Specifically, at the end of their instructions, HAA state,

> At the end of the game, if you have not selected all spades, we will pay you for the cards you have selected, and you will refund us money for the spades you have not selected.

Our design of alternative phrasing is based on HAA reporting of results from follow-on experiments, which they interpret as indicating that an explicit linkage between amounts of money and choices of particular cards is important for the prepayment effect to operate. In our treatment **Pre+Amount+Instr**, we therefore replace the above sentence with the following text intended to highlight that linkage:

> For each set of four playing cards, there are three possible scenarios:
>
> - There is not a spade among the four cards. Then, at the end of the session, you will receive a payment for that set equal to the value of the card you select.
> - There is a spade among the four cards, but you select a different card. Then, at the end of the session, you will pay us back from your up front payment an amount equal to the value of the spade, and you will receive a payment from us equal to the value of the card you did select.
> - There is a spade among the four cards, and you select the spade. Then, because you have already received payment for that spade card in your up front payment, you will not pay us back anything for that set, nor will you receive any additional payment for that set.

Hypothesis 3. *The treatment effect is robust to instructions; the maximization rates will be comparable in **Pre+Amount** and **Pre+Amount+Instr**.*

	Information on total value	Advance payment	Instructions same as HAA
Post	No	No	Yes
Post+Amount	Yes	No	No
Pre+Amount	Yes	Yes	Yes
Pre+Amount+Instr	Yes	Yes	No

Table 1: Summary of experimental treatments.

2.3 Effects of prior experience

We now turn our attention to the characteristics of the decision-makers themselves. Our next hypothesis concerns the role of experience. The card choice task in HAA is simple. It is also artificial, in the sense that the rules for determining valuations of the cards are not drawn from a game or situation that exists "in the wild." Participants cannot draw on prior experience with the task or very similar ones, in the way that an economic agent might draw on experience in understanding the implications of prepayment arrangements for commissions.

The artificiality of the task is a useful feature, in that it allows the construction of a decision problem with the most minimal amount of complexity arising from the lack of a common standard.[5] While we cannot easily address the role that familiarity with this specific task might play in the persistence of the prepayment effect, we can ask whether participants who have previous experience with economic experiments behave differently.

Previous experience might predict behavior for two reasons. First, previous experience may affect expectations about how lab experiments operate in a generalized sense. Experience has been shown to have an effect in, for example, public goods games (Conte et al., 2014) and allocation games (Matthey and Regner, 2013). Some of the effect of experience in games would be due to more accurate beliefs about the play of others, an aspect that is absent in this individual decision task. Nevertheless prior experience may be valuable, insofar as participants will have familiarity with general lab procedures, including how to read and extract relevant information from instructions. Participants with prior experience also have self-selected into coming back to the laboratory. Abeler and Nosenzo (2014) have studied self-selection into participant pools and report that interest in monetary rewards appears strongly to drive participation.

Both channels would suggest experienced participants would be more likely to maximize earnings. To explore the possible role of experience with experiments, we conducted a stratified recruiting strategy. We identified very experienced participants as those who had participated at least 10 times previously in experimental sessions, and somewhat less experienced participants as those

[5] Schram (2005) is a good discussion of the tradeoffs between internal and external validity arising from the artificiality of laboratory games.

who had participated no more than 5 times. We recruited approximately equal numbers of participants from these two subpopulations. Those who had participated 6 to 9 times were not recruited, to give a more clear distinction between the groups.

Hypothesis 4. *Participants with greater experience in experiments will have higher maximization rates in prepayment treatments.*

2.4 Effects of confidence at the specific task

The distant representation condition we focus on in our experiment is one of three conditions in the full Experiment 1A design of HAA. In their close representation condition, payoffs were represented not by playing cards, but directly expressed as amounts of money. In the moderate representation condition, payoffs were depicted using playing cards, but with a label indicating their monetary value. HAA find evidence of the prepayment effect only in the distant representation condition.

The distant representation requires a particular type of operation, mathematical calculation, for participants to infer the earnings consequences of the options they face. The arithmetic required is taught at an early age in schools, and can be taken as part of the assumed skills an undergraduate student at a university would have. Although the arithmetic is straightforward enough, studies such as Pajares and Miller (1994) have noted that many adults dislike and avoid math, even those who are competent at calculation. Ashcraft (2002) observes effects of math anxiety even on simple whole-number arithmetic problems. It has been argued that math anxiety could shape individuals' behavior when facing challenging circumstances (Bandura, 1977).

The design of the card choice task requires participants to carry out, on demand, a mathematical calculation in the context of a novel setting not previously encountered. Prepayment may be an effective tactic when the task to determine the earnings-maximizing choice requires an activity the decision-maker is disinclined to carry out. To investigate this, within a battery of demographics questions asked at the end of the session, after all choices were made, we included a question asking participants, "Do you consider yourself good at mathematics?" This was implemented as a radio box, with options for Yes, No, or "Prefer not to say" as the possible responses. Such self-reports of mathematical skill have been used as a behavioral indicator in economics and psychology (e.g. Ashcraft and Kirk, 2001; Ashcraft and Ridley, 2005; Marsh et al., 2012; Buser et al., 2014).[6]

Hypothesis 5. *Participants who report confidence in their ability to carry out mathematical calculations will have higher maximization rates.*

[6]We prefer the participant's self-reported confidence level rather than their actual mathematical ability. We placed no time restrictions or pressures on the individual decisions, and we are confident our students are capable, in principle at least, of carrying out the required calculations correctly. Our hypothesis instead centers around the possibility that some participants feel less attracted or inclined to engage with the required computational task.

3 Results

We report on 206 participants who participated in the task. The results in HAA focus on the rate of maximization by participants in the two "low-spades" trials, in which a spade card is present but is not the earnings-maximizing choice. We report this measure for each treatment in Table 2, where we also present breakouts of the low-spade maximization rate overall for each demographic characteristic. As the breakouts by demographic are averaged over all treatments, the maximization rates presented are only indicative.

The breakdown of males (44.2%) and females[7] is comparable to our participant pool and the University's student body as a whole. Among the 94 very-experienced participants (10 or more previous sessions), 44 (46.8%) are male, while among the 112 less-experienced participants, 47 (43.8%) are male; the difference in composition is not statistically significant (Fisher's exact test $p = 0.667$) and again mirrors the participant pool. Less-experienced participants had participated, on average, in 1.78 previous sessions, while the very-experienced participants had been in 15.67 previous sessions on average. A total of 106 (51.5%) considered themselves good at mathematics, with 86 (41.7%) saying they were not; 14 preferred not to say. Self-reported mathematics confidence is independent of whether the participant was among the highly-experienced cohort; Fisher's exact test does not reject the null hypothesis that the responses to the math confidence question have the same distribution in both groups (p-value 0.904). We observe a relationship between gender and reported math confidence: 61.5% of males (56 in total) answered in the affirmative as opposed to 43.9% of females (50 in total), which is in line with previous results (Eccles, 1998; Buser et al., 2014).[8]

The rightmost three columns in Table 2 break out the proportion of participants who maximize on zero, one, or both of the low-spades trials.[9] In general, the modal outcome for a participant is to maximize on both low-spades trials, with maximizing on exactly one of the two being more likely than failing to maximize on either.[10]

Result 1 *We replicate HAA's result that the maximization rate on low-spades trials is lower in* ***Pre+Amount*** *than in* ***Post****. The maximization rate in* ***Pre+Amount*** *is comparable in our data to HAA's, but we observe a significantly lower maximization rate in* ***Post****. As a result, the magnitude of the treatment effect is smaller in our data.*

[7] One participant declined to disclose their gender.

[8] Fisher's exact test rejects the null hypothesis of independence between gender and reported math level (p-value 0.008).

[9] A more detailed summary of distributions of choices broken down by each of the seven sets is in Appendix C.

[10] The lone exception is students on economics degree courses, in which 2 of the 25 participants failed to maximize on either low-spades trial and 1 maximized on exactly one of the two.

Subsample	Value	N	Overall max rate	Participants maximizing 0 times	1 time	2 times
HAA results	**Post**	61	95.1%			
HAA results	**Pre+Amount**	50	66.0%			
Our sample, all participants		206	70.6%	15.5%	27.7%	56.8%
Treatment	**Post**	49	79.6%	10.2%	20.4%	69.4%
Treatment	**Post+Amount**	49	73.5%	10.2%	32.7%	57.1%
Treatment	**Pre+Amount**	54	60.2%	22.2%	35.2%	42.6%
Treatment	**Pre+Amount+Instr**	54	70.4%	18.5%	22.2%	59.3%
Math-confident	No	86	59.3%	22.1%	37.2%	40.7%
Math-confident	Yes	106	78.8%	12.2%	17.9%	69.8%
Math-confident	Decline to say	14	78.6%	0.0%	42.9%	57.1%
Prior experience	0 sessions	32	64.1%	21.9%	28.1%	50.0%
Prior experience	1 to 5 sessions	80	72.5%	13.8%	27.5%	58.8%
Prior experience	10 or more sessions	94	71.3%	14.9%	27.7%	57.5%
Gender	Female	114	66.2%	19.3%	29.0%	51.8%
Gender	Male	91	76.4%	11.0%	25.3%	63.8%
Native English speaker	No	73	66.4%	19.2%	28.8%	52.1%
Native English speaker	Yes	130	74.2%	12.3%	26.9%	60.8%
Degree course	Not economics	179	67.6%	16.8%	31.3%	52.0%
Degree course	Economics	25	90.0%	8.0%	4.0%	88.0%

Table 2: Low-spade maximization rates, disaggregated by treatments and demographic characteristics. The first two rows report the comparable results from HAA. Not all demographics breakouts of our data add up to $N = 206$ due to blank responses.

Support. We follow HAA's analysis by considering low-spades trials, and reporting the percentage of choices in those trials in which the participant chose the earnings-maximizing card. Table 2 reports a maximization rate of 79.6% in **Post**, which decreases to 60.2% in **Pre+Amount**. We reject the null hypothesis that these rates are the same (using the Mann-Whitney test with the individual participant as the unit of observation; $p = 0.007$).

The overall maximization rates on low-spades trials in **Pre+Amount** are similar in our data (60.2%) and HAA's (66.0%); these are not statistically different (p-value for two-tailed test of proportions 0.542). Our results differ significantly in **Post**, where HAA report a 95.1% maximization rate as opposed to our 79.6% (p-value 0.012). □

Participants in both subject pools maximize significantly less often on low-spades trials in **Pre+Amount** than in **Post**. The salient difference is that HAA's participants choose the earnings-maximizing card in these trials significantly more often in **Post** than do ours. One possible driver of this result is differences in the participant pools. HAA conducted their experiments at Duke University, a private institution that is one of the most selective in the United States. Our replication was done at a middle-tier public university in the United Kingdom, which is best known for its degree programs in areas such as literature and creative writing, and which offers no engineering or physics courses at all.

While we are unable to make a direct comparison with the backgrounds of the participants in HAA's experiment, we can look for some indirect evidence using the demographic information we obtained from our participants. To test the remaining hypotheses, we report an ordered probit regression. For each participant, the dependent variable is the number of low-spades trials on which the participant chose the earnings-maximizing card. We include dummies for each of the three treatment characteristics **Pre**, **Amount**, and **Instr**.

To address the experience hypothesis (Hypothesis 4), we define two variables. We set the variable Very experienced $= 1$ for those participants who were recruited based on having been in at least 10 prior experiment sessions. We additionally define Any experience $= 1$ for participants who had previously participated in at least one session. In our coding, Very experienced $= 1$ implies Any experience $= 1$, so the incremental effect of extensive experience can be read out directly from the regression.

We test Hypothesis 5 on the influence of self-confidence in mathematics by including the response to the math confidence question. We take a response of "No" as the baseline, and encode Math-confident $=$ Yes and Math-confident $=$ Decline as separate levels.[11]

In addition, we include other demographic characteristics which plausibly could correlate with

[11] This question was posed as a radio box, and participants were required to respond either "Yes", "No," or "Decline to say." As all participants necessarily made a response to this question, we believe it is more faithful to the design to treat these as three levels, rather than to treat "Decline to say" as a null response.

maximization rates. To control for possible gender effects, we include whether the participant is male (Male = Yes). As comprehension of the instructions is relevant, we include whether the participant identified as a native speaker of English (Native speaker = Yes). Finally, we include a control for whether the participant is a student in the School of Economics (Economics = Yes). The parameter estimates are reported in Table 3. In the specification in which we use demographic information, we omit the five participants who gave a null response to one or more of these three questions.

To aid in interpreting the results of the regression, in Table 4 we report the predicted proportion of earnings-maximizing choices in low-spades trials, for each treatment, depending on the values of Male and Math-confident.

Result 2 *The mere mention of the total value of spades does not significantly affect behavior in postpayment conditions.*

Support. In all specifications, the estimated coefficient on the dummy variable **Amount** is not statistically different from zero. This is consistent with the comparison between the overall low-spade maximization rate of 73.5% in treatment **Post+Amount** and the 79.6% observed under **Post**. □

Result 3 *The effect of alternate instructions is significant. The alternate instructions emphasizing the link between each set and payment lead to higher maximization rates.*

Support. The low-spade maximization rate in **Pre+Amount+Instr** is 70.4%, as compared to 60.2% in **Pre+Amount**. In the regression, the coefficient on the instructions dummy variable **Instr** is positive, and significant in all specifications using demographic controls. □

If one takes the view that failing to choose the earnings maximizing card is a mistake on the part of the agent,[12] then alternative phrasings may serve to de-bias the decision maker. These effects have been explored in psychology (e.g. Evans et al., 1994), law (e.g. Babcock et al., 1997), and accounting (e.g. Clarkson et al., 2002) as well as economics (e.g. List, 2001). In the case of the instructions used in Treatment **Pre+Amount+Instr**, explicitly stepping through the process by which payments will be realized might influence whatever processes participants use to come to their decisions.

[12]For the purposes of this paper, we put to one side the question of normative implications. If a decision-maker is truly loss-averse, then choosing the non-earnings-maximizing card might be viewed as optimal from the perspective of their preferences. McQuillin and Sugden (2012) provide one survey of the issues in reconciling behavioural and normative economics.

Variable	(1)	(2)	(3)	(4)
Pre	-0.394	-0.455**	-0.579**	-0.615**
(Prepayment received)	(0.228)	(0.231)	(0.246)	(0.253)
Instr	0.317	0.588**	0.540**	0.670***
(Rephrased instructions)	(0.223)	(0.238)	(0.241)	(0.251)
Amount	-0.239	-0.267	-0.146	-0.119
(Total spade value mentioned)	(0.246)	(0.250)	(0.263)	(0.269)
Math-confident = Yes		0.729***	0.731***	0.600***
		(0.181)	(0.182)	(0.188)
Math-confident = Decline		0.758**	0.838**	0.873**
		(0.351)	(0.354)	(0.381)
Any experience			0.424	0.517*
(Experience > 0)			(0.278)	(0.284)
Very experienced			-0.083	-0.122
(Experience ≥ 10)			(0.187)	(0.194)
Gender = Male				0.306*
				(0.180)
Native speaker = Yes				0.271
				(0.180)
Economics student = Yes				0.839**
				(0.343)
Constant cut 1	-1.346	-0.969	-0.634	-0.283
Constant cut 2	-0.482	-0.057	-0.286	0.689
Observations	206	206	206	201
Log-likelihood	-195.215	-186.463	-185.278	-173.580
Pseudo R^2	0.019	0.063	0.069	0.100

Table 3: Ordered probit regression for determinants of maximization behavior on low-spades trials. The unit of observation is the individual participant; the dependent variable is the number of low-spades trials on which that participant chose the earnings-maximizing card. Standard errors reported in parentheses. * denotes significantly different from zero at 10%; ** at 5%; *** at 1%.

	Math-confident = Yes		Math-confident = No	
	Male	Female	Male	Female
Post	88.9%	81.2%	72.9%	63.8%
Post+Amount	86.9%	78.3%	69.3%	59.9%
Pre+Amount	72.5%	60.2%	49.1%	38.8%
Pre+Amount+Instr	87.9%	79.7%	71.0%	61.7%

Table 4: Predicted low-spade maximization rate, by gender and reported mathematics self-confidence.

Result 4 *Participants who have never previously participated in an experiment are less likely to choose earnings-maximizing cards. Conditional on having any previous experience, however, there is no effect of additional experience; participants who have participated in 10 or more previous sessions are no more likely to maximize earnings than those who have been in 1 to 5 sessions previously.*

Support. The coefficient on Prior experience in Table 3 is positive and significant at the 5% level. The coefficient on Very experienced is not significantly different from zero. These are consistent with the aggregate maximization rates in Table 2, in which participants with no prior experience had a maximization rate of 64.1%, compared to 72.5% for those with 1 to 5 previous sessions and 71.3% for those with 10 or more previous sessions. □

Result 5 *Reported mathematics confidence is a strong predictor of the likelihood to choose earnings-maximizing cards in low-spades trials.*

Support. The coefficient on Math-confident = Yes in Table 3 is positive and significant at the 1% level. The magnitude is large; as can be seen from the predictions in Table 4, participants who indicated confidence in their mathematics ability choose earnings-maximizing cards between roughly 10% to 20% more often, mirroring the aggregate advantage observed by math-confident participants as reported in Table 2. The response to this question alone can account for about 50% of the non-earnings-maximizing card choices in low-spades trials.

We also find that participants who declined to characterize themselves as either good or not good at math maximized at a rate comparable to those who responded yes to the question. While we cannot offer an account of why this is the case, in our data it is an explicit "no" response to this question that signals a significant difference in behavior. □

We close by remarking briefly on the other demographics. We did not have hypotheses in mind regarding these when designing the experiment, so these observations are post-hoc. As such we do not state them as formally numbered results, and our commentary is intended to suggest hypotheses for future research.

Males do choose earnings-maximizing cards more often than females, even when controlling for stated mathematics self-confidence.[13] On the one hand, this contrasts with results indicating males are overconfident in their ability to do mathematics (e.g. Niederle and Vesterlund, 2007). However, Barber and Odean (2001) found that, in financial markets, men trade more than women; the significance of the gender variable may reflect a willingness among males to "trade away" from spades.

[13] We note that all sessions were led by the same female experimenter.

We observe (with admitted pleasure) that students in economics maximize earnings significantly more often. Among economics students, 18 (72.0%) identified as being good at mathematics, and 3 (12.0%) declined to say. Among students from other schools, 86 (48.0%) said they were good at mathematics, and 11 (6.2%) declined to say. These distributions are significantly different ($p = 0.009$ using Fisher's exact test). Friesen and Earl (2015) found that students with economics training perform better in tasks involving choices with multipart tariffs. In the UK university system, students do not in general take courses on other subjects, and so we can say that non-economics students in our sample would be unlikely to have much undergraduate-level training in economic reasoning. Nevertheless, we cannot distinguish whether the effect would be due to selection of students into the economics program, or whether training in the type of economic models that motivate experiments in economics makes students more likely to recognize and choose the earnings-maximizing card.

4 Conclusion

HAA reported a striking result: in a simple choice task with no objective risk, participants were less likely to choose earnings-maximizing cards when they received a prepayment based on some other, non-earnings-maximizing choice. We have shown this effect is qualitatively robust, even with a different participant pool and somewhat higher incentives.

Given the apparently straightforward calculations required to maximize earnings in this decision task, it is remarkable that undergraduate students both at Duke (HAA) and University of East Anglia (this paper) would, overall, leave money on the table. We therefore take a closer look at this decision task, both to map out the extent to which maximization rates depend on details of the experimental protocol, and to understand better whether certain types of participants are less likely to maximize earnings.

We find that the effect of prepayment does depend on the description of the experimental task. The methodological observation that participant decisions are not independent of instructions is hardly novel, but the potential practical implications are noteworthy. We can think of the description of the experimental task as the analog of the description of offers to consumers or terms and conditions of agency contracts. One interpretation of HAA's results and our replication is that it is easy to influence decisions, even when there is no objective risk and the choice architecture is not very complex. HAA's instructions, used in the **Pre+Amount** treatment, while brief, are not overtly misleading. Our **Pre+Amount+Instr** instructions are somewhat more explicit, which may serve a debiasing function. A regulator whose objective was to keep people from making apparently suboptimal decisions might find descriptions similar to ours preferable because of their debiasing

effects. However, creating effective written communication is challenging.[14] Because instructions like HAA's are not overtly misleading, and because the effect of written communication on an audience is difficult to judge, even by experienced writers, the regulator might find it difficult to distinguish between well-intentioned but unclear writing, as opposed to deliberate obfuscation.

We also find that characteristics of the participant are strong predictors of the maximization rate. Participants who state they do not consider themselves to be good at math maximize far less frequently; the magnitude of the difference is comparable to the magnitude of the prepayment effect between **Post** and **Pre+Amount**. HAA only observed the prepayment effect when participants needed to carry out mathematical calculations to determine the values of the cards.

Experience can sometimes serve to correct apparent errors in judgment or decisions made by relatively inexperienced decision-makers. Participants who have been in previous lab experiments have some experience with processing the information in experimental instructions, which are the terms and conditions under which experimenters offer participants the chance to earn money. We find at most a modest effect of general experience in laboratory experiments on performance in this task.

This simple choice task devised by HAA generates an interesting amount of variation in performance, depending on how it is presented, and on the characteristics of the decision-makers. The task is sufficiently stylized that broad claims about external validity should be tempered. However, the stark simplicity of the setting helps to illustrate some possible subtle mechanisms firms could use to influence the behavior of agents or consumers, with corresponding implications for the problems that market designers or regulators face in evaluating the appropriateness of the structure of contracts or offers.

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A Comparison of instructions

In this appendix, we provide the full text of the instructions for each of the four treatments. In addition, we provide the instructions as used by Hochman et al. (2014) for comparison.

A.1 Treatment Post

A.1.1 This paper

This is an experiment in the economics of decision making. If you follow the instructions and make appropriate decisions, you can earn an appreciable amount of money. You will receive your earnings for today's session in cash before you leave the laboratory.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

We will now describe the session in more detail. Please follow along with these instructions as they are read aloud.

On your computer monitor, you will be given sets of four playing cards, face-up, several times. Each time, you will select and keep one card.

After all of these sets are completed, you will be paid based on the cards you have selected. Each card is worth its point value times 10p, so a three is worth three times 10p, a nine is worth nine times 10p, et cetera. Aces are worth 10p, jacks are worth eleven times 10p, queens are worth twelve times 10p, and kings are worth thirteen times 10p.

However, those values apply only to cards that are NOT spades. Spades (♠) are worth their point value times 25p, not 10p. The ace of spades is worth 25p, the two of spades is worth two times 25p, and so on.

At the end of the game, we will pay you for the cards you have selected.

A.1.2 HAA

Thank you for your participation. Feel free to ask questions at any time if anything is unclear. There are no tricks or catches to this game, we simply ask that you pay attention to the instructions and think carefully about your decisions. You will be paid some amount of money at the end of the game; how much you are paid will be determined by the decisions you make.

You will be given sets of four playing cards, face-up, several times. Each time, you will select and keep one card.

After all of these sets are completed, you will be paid based on the cards you have selected.

Each card is worth its point value in dimes, so a three is worth three dimes, a nine is worth nine dimes, et cetera. Aces are worth one dime, jacks are worth eleven dimes, queens are worth twelve, and kings are worth thirteen.

However, those values apply only to cards that are NOT spades. Spades are worth their point value in quarters, not dimes. The ace of spades is worth one quarter, the two of spades is worth two quarters, and so on. We have placed the cards ace through five of spades in the deck randomly.

At the end of the game, we will pay you for the cards you have selected.

A.2 Treatment Post+Amount

This is an experiment in the economics of decision making. If you follow the instructions and make appropriate decisions, you can earn an appreciable amount of money. You will receive your earnings for today's session in cash before you leave the laboratory.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

We will now describe the session in more detail. Please follow along with these instructions as they are read aloud.

On your computer monitor, you will be given sets of four playing cards, face-up, several times. Each time, you will select and keep one card.

After all of these sets are completed, you will be paid based on the cards you have selected.

Each card is worth its point value times 10p, so a three is worth three times 10p, a nine is worth nine times 10p, et cetera. Aces are worth 10p, jacks are worth eleven times 10p, queens are worth twelve times 10p, and kings are worth thirteen times 10p.

However, those values apply only to cards that are NOT spades. Spades (♠) are worth their point value times 25p, not 10p. The ace of spades is worth 25p, the two of spades is worth two times 25p, and so on. We have placed the cards ace through five of spades in the deck randomly. The value of the five spades, ace through five, equals a total of three pounds and seventy-five pence: one plus two plus three plus four plus five is fifteen times 25p i.e. three pounds and seventy-five pence.

At the end of the game, we will pay you for the cards you have selected.

A.3 Treatment Pre+Amount

A.3.1 This paper

This is an experiment in the economics of decision making. If you follow the instructions and make appropriate decisions, you can earn an appreciable amount of money. You will receive your earnings for today's session in cash before you leave the laboratory.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

We will now describe the session in more detail. Please follow along with these instructions as they are read aloud.

On your computer monitor, you will be given sets of four playing cards, face-up, several times. Each time, you will select and keep one card.

After all of these sets are completed, you will be paid based on the cards you have selected. Each card is worth its point value times 10p, so a three is worth three times 10p, a nine is worth nine times 10p, et cetera. Aces are worth 10p, jacks are worth eleven times 10p, queens are worth twelve times 10p, and kings are worth thirteen times 10p.

However, those values apply only to cards that are NOT spades. Spades (♠) are worth their point value times 25p, not 10p. The ace of spades is worth 25p, the two of spades is worth two times 25p, and so on. We have placed the cards ace through five of spades in the deck randomly.

The value of the five spades (ace through five) equals a total of three pounds and seventy-five pence: one plus two plus three plus four plus five is fifteen times 25p i.e. three pounds and seventy-five pence. We will give you this amount up front.

However, if you do not choose all of the five spade cards, you will need to give us back some of this money at the end of the game. The amount you return will be the value of the spade card(s) that you did NOT choose.

For example, if you do not pick up the three of spades, you will return three times 25p to us from your three pounds and seventy-five pence.

At the end of the game, if you have not selected all spades, we will pay you for the cards you have selected, and you will refund us money for the spades you have not selected.

A.3.2 HAA

Thank you for your participation. Feel free to ask questions at any time if anything is unclear. There are no tricks or catches to this game, we simply ask that you pay attention to the instructions

and think carefully about your decisions. You will be paid some amount of money at the end of the game; how much you are paid will be determined by the decisions you make.

You will be given sets of four playing cards, face-up, several times. Each time, you will select and keep one card.

After all of these sets are completed, you will be paid based on the cards you have selected. Each card is worth its point value in dimes, so a three is worth three dimes, a nine is worth nine dimes, et cetera. Aces are worth one dime, jacks are worth eleven dimes, queens are worth twelve, and kings are worth thirteen.

However, those values apply only to cards that are NOT spades. Spades are worth their point value in quarters, not dimes. The ace of spades is worth one quarter, the two of spades is worth two quarters, and so on. We have placed the cards ace through five of spades in the deck randomly.

The value of the five spades (ace through five) equals a total of three dollars and seventy-five cents: one plus two plus three plus four plus five is fifteen quarters i.e. three dollars and seventy five cents. We will give you these fifteen quarters up front.

However, if you do not choose all of the five spade cards, you will need to give us back some of this money at the end of the game. The amount you return will be the value of the spade card(s) that you did NOT choose.

For example, if you do not pick up the three of spades, you will return three quarters to us from your three dollars and seventy-five cents.

At the end of the game, if you have not select all spades, we will pay you for the cards you have selected, and you will refund us money for the spades you have not selected.

A.4 Treatment Pre+Amount+Instr

This is an experiment in the economics of decision-making. If you follow the instructions and make appropriate decisions, you can earn an appreciable amount of money. You will receive your earnings for today's session in cash before you leave the laboratory.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

We will now describe the session in more detail. Please follow along with these instructions as they are read aloud.

On your computer monitor, you will be given sets of four playing cards, face-up, several times. No card will appear more than one time during the experiment. Each time, you will select and keep one card. After all of these sets are completed, you will be paid based on the cards you have

selected.

The value of a card to you depends on the card's suit and point value. Spades (♠) are worth their point value times 25p. The ace of spades is worth 25p, the two of spades is worth two times 25p, and so on.

We have placed the cards ace through five of spades in the deck randomly. The values of these five spades (ace through five) equal a total of three pounds and seventy-five pence, because one plus two plus three plus four plus five is fifteen times 25p is three pounds and seventy-five pence. We will give you this amount up front.

Cards of the other suits, hearts (♡), diamonds (♢), and clubs (♣), are worth their point value times 10p. So, a three is worth three times 10p, a nine is worth nine times 10p, et cetera. In these suits, aces are worth 10p, jacks are worth eleven times 10p, queens are worth twelve times 10p, and kings are worth thirteen times 10p.

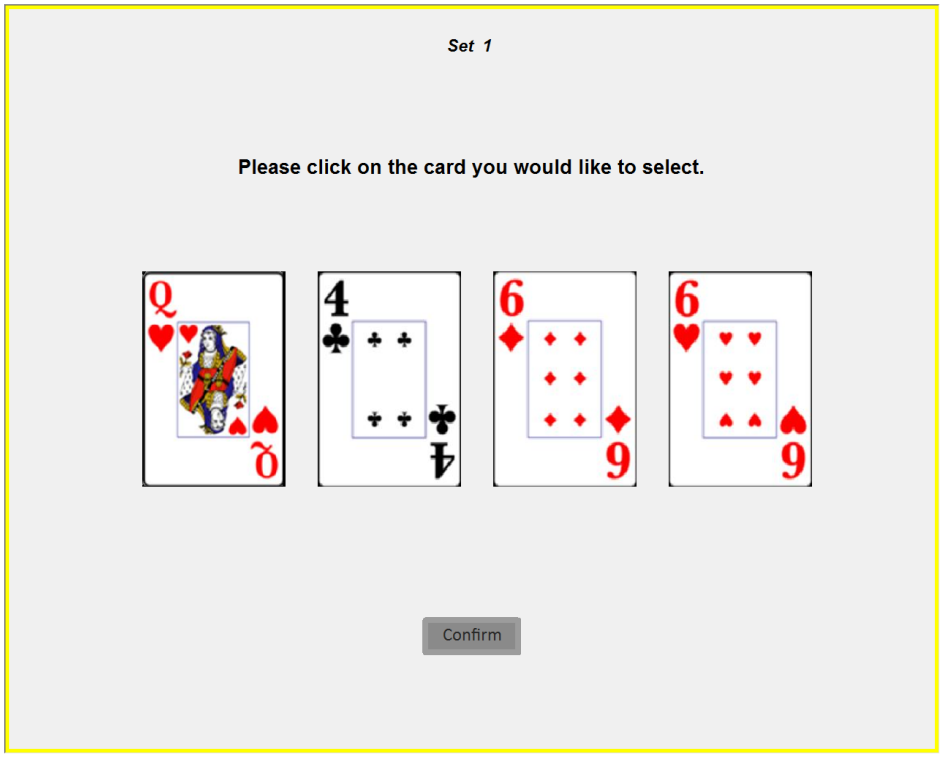
At the end of the experiment, you will leave the lab with a total payment equal to the sum of the values of the cards you select. For each set of four playing cards, there are three possible scenarios:

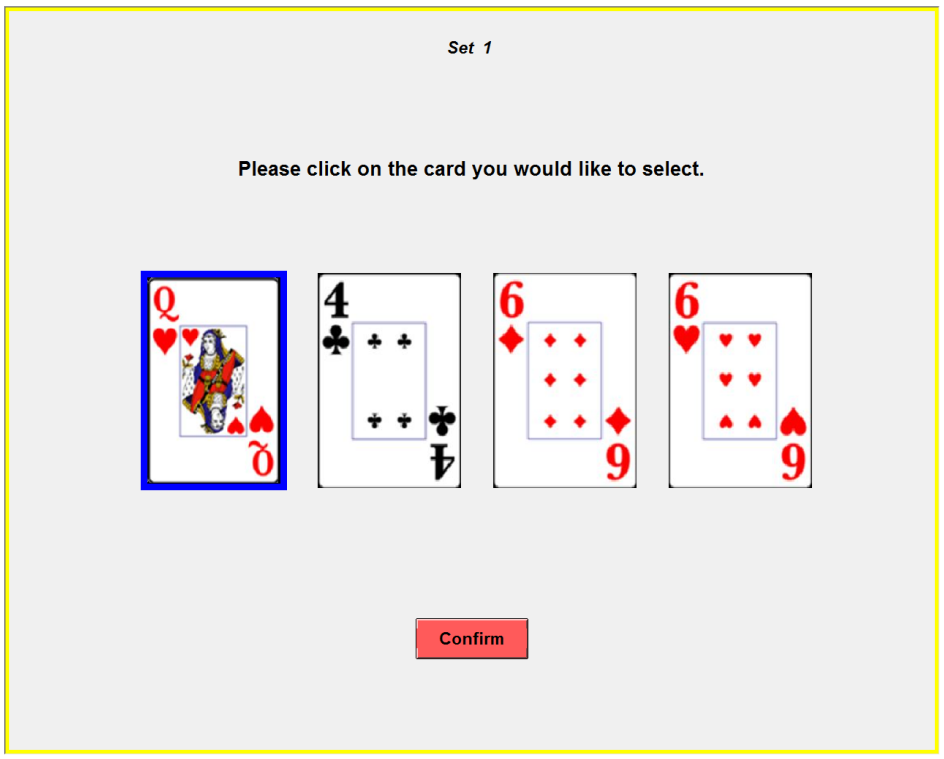
- There is not a spade among the four cards. Then, at the end of the session, you will receive a payment for that set equal to the value of the card you select.

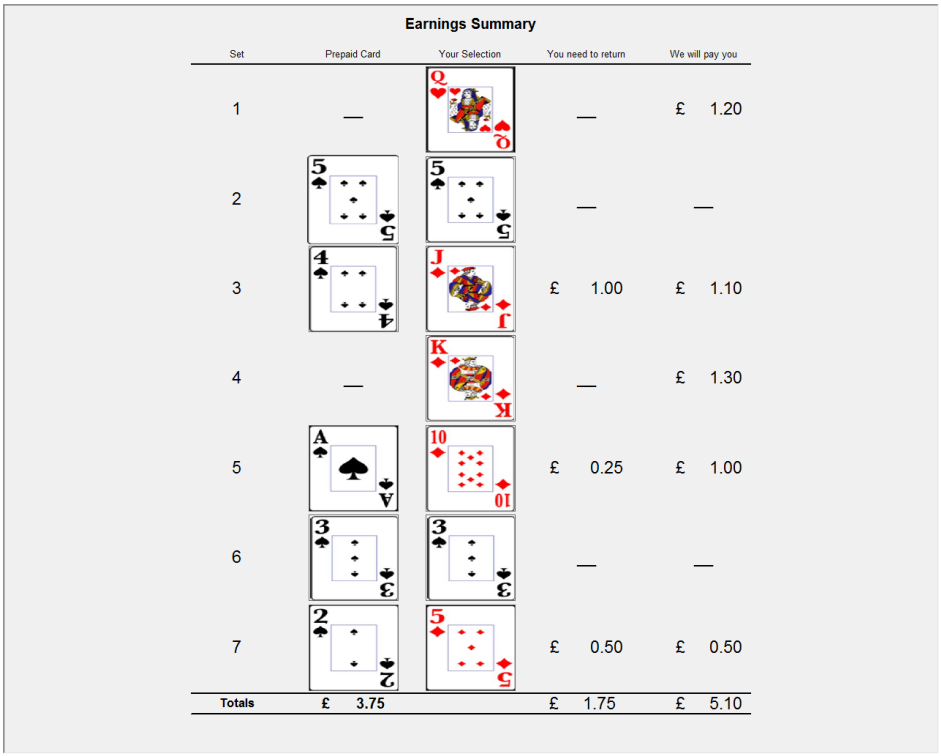
- There is a spade among the four cards, but you select a different card. Then, at the end of the session, you will pay us back from your up front payment an amount equal to the value of the spade, and you will receive a payment from us equal to the value of the card you did select. For example, if you did not select three of spades but instead select four of diamonds; we will pay you 40p corresponding to the four of diamonds and you need to refund us 3 times 25p corresponding to the three of spades.

- There is a spade among the four cards, and you select the spade. Then, because you have already received payment for that spade card in your up front payment, you will not pay us back anything for that set, nor will you receive any additional payment for that set.

B Screenshots of participant interface







C Choice distributions at the set level

In this appendix we provide a more detailed view on the seven sets of cards faced by the participants. In each table, the first row shows the four cards that were used in the set. The next row contains the values of the cards; the data for the card(s) which maximize earnings are displayed in bold. The total number of choices and corresponding frequencies for each card are presented for each treatment, **Post**, **Post+Amount**, **Pre+Amount**, and **Pre+Amount+Instr**, in separate rows, recalling that **Post** and **Pre+Amount** are replications of HAA's.

Set 1	Q♡		4♣		6♢		6♡	
Value	**GBP 1.20**		GBP 0.40		GBP 0.60		GBP 0.60	
Post	**94%**	**46**	4%	2	2%	1	0%	0
Post+Amount	**88%**	**43**	8%	4	2%	1	2%	1
Pre+Amount	**96%**	**52**	4%	2	0%	0	0%	0
Pre+Amount+Instr	**87%**	**47**	6%	3	7%	4	0%	0

Set 2	2♡		3♢		5♠		3♡	
Value	GBP 0.20		GBP 0.30		**GBP 1.25**		GBP 0.30	
Post	0%	0	0%	0	**100%**	**49**	0%	0
Post+Amount	0%	0	6%	3	**94%**	**46**	0%	0
Pre+Amount	0%	0	2%	1	**98%**	**53**	0%	0
Pre+Amount+Instr	0%	0	7%	4	**93%**	**50**	0%	0

Set 3	J♢		4♠		7♡		9♡	
Value	**GBP 1.10**		GBP 1.00		GBP 0.70		GBP 0.90	
Post	**73%**	**36**	27%	13	0%	0	0%	0
Post+Amount	**71%**	**35**	29%	14	0%	0	0%	0
Pre+Amount	**54%**	**29**	46%	25	0%	0	0%	0
Pre+Amount+Instr	**65%**	**35**	30%	16	2%	1	4%	2

Set 4	J♣		K♢		7♢		6♣	
Value	GBP 1.10		**GBP 1.30**		GBP 0.70		GBP 0.60	
Post	2%	1	**98%**	**48**	0%	0	0%	0
Post+Amount	6%	3	**92%**	**45**	0%	0	2%	1
Pre+Amount	2%	1	**96%**	**52**	0%	0	2%	1
Pre+Amount+Instr	2%	1	**96%**	**52**	2%	1	0%	0

Set 5	4♡		10♢		A♠		8♡	
Value	GBP 0.40		**GBP 1.00**		GBP 0.25		GBP 0.80	
Post	0%	0	**86%**	**42**	14%	7	0%	0
Post+Amount	0%	0	**76%**	**37**	22%	11	2%	1
Pre+Amount	0%	0	**67%**	**36**	31%	17	2%	1
Pre+Amount+Instr	0%	0	**76%**	**41**	20%	11	4%	2

Set 6	3♠		2♣		A♢		4♢	
Value	**GBP 0.75**		GBP 0.20		GBP 0.10		GBP 0.40	
Post	**86%**	**42**	0%	0	4%	2	10%	5
Post+Amount	**67%**	**33**	0%	0	12%	6	20%	10
Pre+Amount	**87%**	**47**	2%	1	0%	0	11%	6
Pre+Amount+Instr	**80%**	**43**	2%	1	6%	3	13%	7

Set 7	5♢		2♢		3♣		2♠	
Value	**GBP 0.50**		GBP 0.20		GBP 0.30		**GBP 0.50**	
Post	**53%**	**26**	0%	0	2%	1	**45%**	**22**
Post+Amount	**41%**	**20**	0%	0	0%	0	**59%**	**29**
Pre+Amount	**7%**	**4**	0%	0	0%	0	**93%**	**50**
Pre+Amount+Instr	**15%**	**8**	0%	0	0%	0	**85%**	**46**