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Older Auctioneers: Performance of Older Users in On-line Dutch Auctions

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Abstract. The number of older adults using e-commerce platform has grown rapidly in recent years. This has created a whole lot of challenges and research problems in the field of adapting e-commerce systems and algorithms to the needs of older adults. In the current study We have conducted an experiment involving 60 older adults whose task was to participate in realistically modeled Dutch auctions. Results show that more advanced age has a clear, statistically significant adverse impact on the overall performance in Dutch auctions, and that need for cognitive closure is correlated with decreased performance in auctions.

Keywords: older adults · dutch auction · e-commerce · decision; risk

1 Introduction

In 2018 people aged 65+ comprise about one fifth of the entire European Union member states' population. The already significant and increasing number of older adults has a high potential as a target group on the digital market. The current value of the so-called "silver economy" is estimated at about 7 trillion dollars per year, which makes it the third largest economy in the world. Older adults living independently will have the largest commercial transaction value of the entire population in the developed countries. Growing part of it take place online.

In this article, we investigate how older adults deal with the risk of looking for bargains on the Internet in the context of time pressure and an awareness of the existence of competition. We decided to use simulated Dutch auctions that are sometimes applied by e-commerce platforms for selling tickets for events or trips³. Our results, to some extent, can also be interpolated to e-commerce scenarios where users have to make decisions regarding an acceptable level of risk in the context of a possible reward under time pressure, and at the same time, learn to predict the behaviour of other users.

We have carried out an experiment involving 60 older adults who participated in simulated Dutch auctions with a realistic user interface. Our research

³ https://www.berksmontnews.com/news/tickets-now-on-sale-for-dutch-auction-on-oct/article_a0f06a68-aad4-11e8-b3d7-8f583153923f.html

was designed to study the actual behaviour of older adults in a controlled environment, enabling a rigorous statistical analysis. We have investigated several factors known from literature, such as cognitive and motivation factors or competition in the auction itself, which might influence older adults' performance in Dutch auctions. To the best of our knowledge, this is the first study of this kind reported in literature.

Our findings show that the performance of older adults in Dutch auctions clearly deteriorates with age. Moreover, this phenomenon is strengthened by the tendency of older adults to avoid uncertainty, which we measured using a psychological scale.

2 Related Work

2.1 Older adults, e-commerce, and Dutch auctions

Research on the use of e-commerce systems by older adults is focused mostly on two interconnected areas: accessibility and acceptance. With help of the Unified Theory of Acceptance and Use of Technology, Lian et al. studied barriers among older adults in Taiwan, and found that performance expectation and social influence have between a strong and moderate positive influence on intentions to shop online [18]. On the other hand, usage barrier, tradition barrier, and risk barrier negatively affect older adults' intentions to shop online. An extensive overview of theoretical and practical studies regarding e-commerce acceptance by older adults can be found in work done by Zhang et al. [29].

Many researchers have studied practical aspects of designing e-commerce systems that would be more older adults friendly. De Lara et al. measured the influence of almost 20 different techniques to make e-commerce web sites more accessible, i.a. explanation of images, selection of colour of links in navigation menus and summarise content [17]. Other researchers proposed a formal framework for assessing e-commerce web object design against guidelines for older adults [21].

Work on deeper adaptation of existing e-commerce systems to the need and limitation of older adults has started only recently. El Shamy et al. [6] proposed an experiment to measure impact of recommender systems and comparison matrices on older adults' e-commerce decisions' quality, but no final results have been published yet. Pawlowska et al. used multi-agent simulation to verify the existence of harmful feedback loop in typical recommendation algorithms, if used by older adults with cognitive limitations [23]. Von Helversen et al. studied the influence of on-line reviews on purchasing decisions of older adults and revealed statistically significant differences in how older and younger people respond to negative reviews [11].

Dutch auctions have been thoroughly studied from a variety of perspectives, but to the best of our knowledge no research regarding behaviors of older adults in such an environment has yet been published. Cox et al. investigated the differences between predictions of theoretical models and bidders behaviour in Dutch

auction[3]. Many factors affect bidders' behaviours, i.a. personality [5] and clock speed [12]. Adam et al. [1] have shown that participation in the Dutch auction can induce excitement, which in turn affects the acceptable level of risk and payoffs.

2.2 Search Demands as moderator of the effect of Aging on Decision Making

Gaining knowledge about possible choice options in complex decision making requires some effort. A number of research findings have indicated that older adults compared to younger ones have a tendency to search for less information in various decision making tasks. For instance, the review by Mara Mather concludes that older adults request less information than younger adults in research on consumer and medical decisions[20]. Additionally, older adults in comparison to younger adults tend to rely more on recognition heuristic and discard further information [22]. Such reduction in information search among older adults may be connected to age-related decrease in cognitive resources and changes in motivation.

Following on that, Mata et al. [19] and Pachur et al. [22] suggest that older adults switch to simpler decision strategies requiring less information, and, therefore, they search less. Furthermore, performance of older adults is better on less complex tasks including smaller set sizes [24]. Therefore, because waiting in Dutch auctions is similar to the search in standard decision tasks, we generally predict that the actual performance in Dutch auctions will be worse in relatively older adults because of their aversion to prolonged information search. However, we predict that such worsening should be observable only in trials when prolonged waiting behaviour was optimal for the actual task performance.

2.3 Need for Cognitive Closure as moderator of the effect of Aging on Decision Making

Need for Cognitive Closure (NFC) is a classical and well established in psychology measure of the epistemic motivation on the inter-individual level. It was defined by Arie Kruglanski as a desire for a definite answer to a question or for any firm answer rather than confusion, uncertainty, or ambiguity, even at the expense of that answer's quality [15, 28]. High NFC individuals prefer order and structure, clarity and certain knowledge. Moreover, they tend to make simplistic decisions, and have problems with adding new knowledge to their views. On the contrary, low NFC individuals are more flexible and open to new information, analyse situations systematically, deal well with uncertainty and ambiguity, and make complex decisions [15, 14, 25].

Several studies have indicated that there is a strong increase in NFC with age, and it is especially true for two NFC subscales, namely Preference for Order and Structure and Preference for Predictability [4, 13, 26]. Nevertheless, even among older adult groups, there can be found individuals with relatively low and relatively high need for cognitive closure. Previous research shows that relatively

~~640~~

Current Price

520

Hotel Beang Resort SPA ****

The hotel offers accommodation in Phuket, just a few steps from the beach. A restaurant and spa are available. Free WiFi is available.

All rooms have air conditioning and a flat-screen TV with satellite channels. Some have sea or city views. Each room has a private bathroom with bathrobes, slippers and free toiletries.

The reception is open 24 hours a day. The property also offers a gift shop, a shared lounge and childcare. You can also play billiards.

The largest cities are 18 km away. Distance from the airport is 23 km.



Fig. 1. Experiment screen showing the course of a single auction.

low NFC is beneficial for performance in the computerized sequential decision tasks, enabling older adults to be more flexible decision makers compared to their high NFC counterparts [26].

3 Experiment Design

Design of our experiment aimed at creating a realistic environment that would require the use of Dutch auctions. To this end, we created a simulated application where participants would bid for hotel rooms. The prices of hotel rooms were discounted over time, and, therefore, these rooms were sold in a Dutch auction. Figure 1 shows the main screen of the experiment. On the left side of the screen depicted on the Figure 1 the start price and current price are presented. The current price drops by 10 PLN (ca. 2 euros) every half a second. On the right side of the screen the name of the hotel, brief description, and three photos are presented. Descriptions and photos were taken from the actual three and four-star hotels.

The Finometer (Finapres Medical Systems, Amsterdam, the Netherlands) was used to collect continuous measures of blood pressure.

Major goal of the experiment design was to create a controlled experiment, which would recreate the effect of competition in a Dutch auction. Letting the participants compete against each other would make it impossible for us to control the auction outcome. Instead, the auction was simulated, and for each auction there was a predetermined, but unknown for participants, closure price.

3.1 Participants

Sixty people participated in the study, including 28 older adults aged 65 to 68 (17 women; mean age = 66,82 years, SD = 1.16) and 32 older adults over 68 years old (23 women; mean age = 70,56 years, SD = 1.41). The level of education was similar for both age groups (mean years of education = 14.57, SD = 2.33 for

Table 1. Time in seconds for subsequent auctions in a decreasing risk scenario. For increasing risk scenario times are the same but in reverse order.

auction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
time (s)	2.5	4	2	3	3.5	5.5	5	6.5	4.5	6	9	7.5	8.5	8	7
auction	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
time (s)	10.5	9.5	11	10	11.5	13	14	12	13.5	12.5	16.5	14.5	15	15.5	16

younger older adults group and mean years of education = 14.75, SD = 2.31 for older adults group). Participants received 12 euros for their participation, which took approx. 1 hour.

3.2 Used Questionnaires

MMSE and NFC. Participants were screened for signs of dementia and other impairments in cognitive functioning by using Mini-Mental State Examination (MMSE, [8]). Only those who scored 27 and more points (out of 30) participated in the study. MMSE examines time and space orientation, memory, attention, language, and ability to follow simple commands.

Participants completed the Need for Cognitive Closure—Short Scale (NFC [15]). In further analyses we used two subscales: Desire for Predictability, Preference for Order and Structure (in total six items). Participants rated how well each of the items described them on a 6-point scale ranging from 1 (totally disagree) to 6 (totally agree). The reliability of those subscales of NFC was satisfactory (Cronbach’s alpha = .70).

3.3 Dutch Auction Task

Participants were asked to make bids in 30 online auctions of hotel rooms. The aim of the task was to make hotel room reservations at the lowest possible price, knowing that one may be forestalled in bidding. We created two subtasks: one with Decreased Risk of failures in auctions and the other one with Increased Risk of failures in auctions. Depending on the condition (between-participants), distribution of the risk of failures was either high at the beginning and decreased throughout the task (Decreased Risk of failures, modeling decreasing competition) or the risk was low at the beginning and increased as the task proceeded (Increased Risk of failures, modeling increasing competition). Participants were not informed about the different task types or aware that a change in the optimal search length could occur. The payoff scheme is presented in Table 1. The possible savings are directly related to the auction time, because the price was falling by 2 euros every half second. For example, in action number 7, the participant could wait a maximum of 5 seconds and save 20 euros.

30 auctions were divided into six blocks with five auctions each. As the main behavioral measure in the Dutch auction task we used the sum of money saved in six phases of the auction task (actual performance).

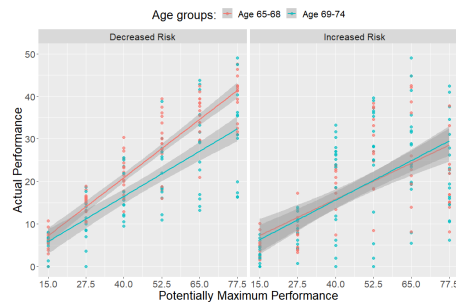


Fig. 2. Actual Performance as the function of Age_Group, potentially Maximum Performance and Condition.

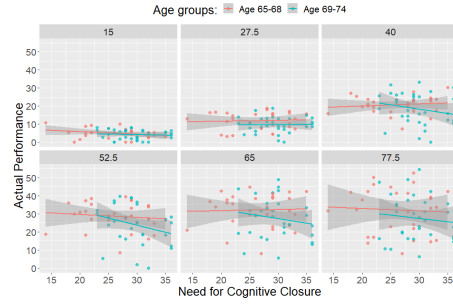


Fig. 3. Actual Performance as the function of Need for Cognitive Closure (NFC) and Age_Group.

3.4 Experiment Procedure

At the beginning of the study, participants filled in an informed consent form. Then MMSE was administered. Subsequently, participants were asked to read the instruction and completed three training trials for the computerised Dutch auction task. In each trial, a participant was to decide when to make a bid while prices within an auction were decreasing with every 0.5 seconds by 2 euros. Each auction could end either by a participant making a bid or because of someone else (i.e. computer) making a bid, as explained to research participants. If a given auction was over before participant made a bid, they had to make hotel room reservation at a standard price (highest price for a particular hotel room compared to the following auction prices), as each of the 30 hotel rooms had to have reservations made. After the Dutch auction task was completed, NFC scale was administered.

4 Results

In the analysis of the auction task data, we focused on actual performance, assessing whether or not participants managed to win Dutch auctions as measured by the sum of money earned in six phases (in total 30 trials) as a dependent variable. Given the structure of the task in which each individual completed 30 auctions grouped in six phases, we used linear-mixed models (LMMs) to investigate if participants differed in their auction behaviour depending on age, as well as individual differences, and how they adapted their behavior over time. Linear-mixed models can incorporate sources of correlation and variability between Dutch auction phases. Linear-mixed models were estimated using the lmer-function (lme4 package [2] and lmerTest package [16]) in R [27].

At the beginning we built a linear-mixed model for actual performance as dependent variable with Condition (Decreased Risk of failures in auctions vs. Increased Risk of failures in auctions) and Maximum Performance (six phases with

regularly increased potential for auction wins) and Age_Group (Older Adults up to the age of 68 vs. Older Adults over the age 68) and their interaction as fixed effects, and Participants as random effect. We fit the linear-mixed models using the restricted maximum likelihood method (REML; [2]) and used the Satterthwaite approximations to estimate the degrees of freedom of the t-tests.

The LMM analysis for actual performance yielded a significant main effect of Maximum Performance, $b = .56$, $SE = 0.04$, $t(296) = 15.82$, $p < .001$ (the higher the potentially maximum performance, the higher the actual performance), a significant main effect of Condition $b = -6.60$, $SE = 1.91$, $t(56) = 3.46$, $p < .002$ (the actual performance in decreased risk condition is higher than in increased risk condition). Furthermore, results of this LMM analysis for actual performance that also yielded a significant main effect of Group_Age (worse performance of older adults over 68 years of age in comparison to younger older adults), $b = -5.12$, $SE = 1.83$, $t(56) = 2.80$, $p < .007$, and interesting and significant Group_Age x Condition x Maximum Performance interaction, $b = .15$, $SE = 0.07$, $t(296) = 2.03$, $p < .05$ (see Figure 2).

The relationship between potentially maximum performance and actual performance was nearly identical for both age groups in the increased risk condition (see Figure 2, right panel). However, the difference in actual performance between age groups (much better actual performance of older adults below the age of 69) is especially evident in the phases of potentially higher maximum performance (see Figure 2, left panel).

To examine the predictions about the compensatory role of the NFC, we added this variable to the linear-mixed model for actual performance. Results of this extended LMM analysis for actual performance yielded significant Group_Age x NFC x Maximum Performance, $b = -.02$, $SE = 0.01$, $t(292) = 1.98$, $p = .05$ interaction (see Figure 3). Inspection of Figure 3 indicates that older adults aged over 68 have similar performance as relatively younger participants, but only when they have relatively low scores in the Need for Cognitive Closure. Increased level of NFC for older adults aged over 68 substantially decreased their actual performance.

Additionally, we assessed cognitive engagement by measuring cardiovascular response. Replicated research demonstrated that systolic blood pressure (sBP) is associated with task engagement (for recent review see [9]). Ennis et al. found that the sBP response (i.e., change from the baseline) was greater for participants reporting high levels of engagement in the tasks and this effect was much stronger in the older adults group than in the younger adults group [7].

Findings in our study show that the relation between continuously collected sBP response and performance in the auction task is moderated by experimental condition (significant interaction between sBP x condition, yielded by the Process software [10]; $t = 2.03$, $p = .04$). Namely, the higher sBP response among participants (i.e., the higher change from the baseline) the better performance but only in the increased risk condition (Pearson's correlation $R = .36$, $p = .03$, one-sided test). Such a relationship was not significant in the decreased risk condition. This interesting finding indicates that the role of subjective engagement

is important in older adults only in the condition (increased risk) where in the beginning the optimal performance demanded relatively long waiting time with the stop response and then adaptive shortening waiting time in later phases. Further research (including younger adults) is needed to demonstrate age differences in engagement for performance of the Dutch auction task.

5 Conclusions

The goal of our work was to investigate how older adults perform in the Dutch auctions. Our findings can be summarized as follows: more advanced age has a clear, statistically significant adverse impact on the overall performance in Dutch auctions. Moreover, need for cognitive closure (measured by the subscales of Desire for Predictability, Preference for Order and Structure), a cognitive motivation variable that is known to increase with age, is also correlated with decreased performance in auctions. In short, older auctioneers often end up paying too much in Dutch auctions because of their cognitive limitations and high need for closure. Our results correspond well with previous findings, but they extend this theoretical knowledge to the domain of e-commerce research.

How can this finding be used to improve the design of Dutch auctions, a commonly used method of many e-commerce systems? Note that strategies in Dutch auctions are completely characterised by an amount of money that an auctioneer is willing to pay for the offered product or service. Theoretical work on auction strategies typically assumes that auctioneers will use a strategy to determine the maximum amount they are willing to pay, and then they will implement the strategy by just waiting for the price to drop to the selected amount. However, for older auctioneers, the waiting itself is the challenge.

Need for cognitive closure can be understood as a desire for quickly making a decision (any decision is better than none). This need of older auctioneers can be accommodated in the design of Dutch auctions in a simple manner. Consider a Dutch auction that allows its participants to look at the product, and then set the price that they are willing to pay for the product or service in advance, without requiring participants to actively wait for the price to drop. When the threshold price specified by an auctioneer is reached in such an auction, the auctioneer's software will automatically place a bid for the product at that price. Such interface would allow older auctioneers to make a decision quickly, and to avoid stressful waiting for the price to drop. Another idea would be to allow older auctioneers to observe auctions of choice without participating – making a decision of not participating, but learning about the bidding process instead.

In future work, we intend to test these ideas to see whether they will allow older auctioneers to improve their performance. We also wish to repeat our experiment with the participation of younger adults, in order to better understand the differences between their strategies and strategies of older auctioneers.

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