Attention, Focus, and Economic Behavior

Dissertation

Markus Georg Schlatterer

University of Bamberg, 1922

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Erstgutachter: Prof. Dr. Florian Herold
Zweitgutachter: Prof. Dr. Marco Sahm
Drittgutachter: Prof. Dr. Guido Heineck

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1 Introduction

Introducing someone to the field of economic theory typically starts by explaining economically rational behavior. Following this track, the assumption of the *homo oeconomicus* as a purely rational decision maker becomes a key concept in the introduction of classical economic models. But while these kinds of models have been and still are useful, a main critique they are faced with is that they often fail to explain real world behavior of human decision makers. Experimental and empirical evidence showed a number of deviations from rational behavior, which resulted in the formation of a new field in economic research: behavioral economics. While, firstly, the field mainly described phenomena and tried to detect the psychological and social underpinnings of those observed behaviors, researchers soon began to include the findings into theoretical models. One of the most influential examples in this direction is the work of Kahneman and Tversky (1979) on prospect theory. Following this tradition, a key cornerstone in one strand of the economic literature is to include the knowledge from scientific fields that investigate the complexity of the human mind into models of economic behavior. This allows economists a more realistic conceptualization of human individuals as decision makers and bridges the gap between classical theory and behavioral economics. The articles included in this dissertation follow this path.

More specifically, one strand of economic research breaks with the classical assumption of perfectly informed economic actors and takes into account that the processing of information itself is a fundamental economic consideration: How to allocate scarce or limited resources. In this context, the limited resources are of a cognitive nature: An economic actor allocates his limited attention towards specific aspects of a decision problem. For example, while searching a supermarket to buy a pack of noodles, a consumer could strictly focus on the prices and ignore other differences like the quality of ingredients or the size of package. Alternatively, because of the limited cognitive capacities, she only perceives a subset of potential alternatives in order to reduce the complexity of the decision making problem. The literature refers to this as consideration sets. In the example of a consumer searching a supermarket for noodles, this could be the case if the consumer does only take noodles of a specific manufacturer into account, restricts his search to specific forms like spaghetti or penne, or simply decides between the first three packs at hand. While this allocation of attention could be the result of active considerations, at times this procedure happens unconsciously. In this case, attention is drawn rather than allocated. Such an automatic reaction to conspicuous stimuli is evolutionary ingrained into the human mind. Modern society still makes use of this fact, e.g., by using flashy colors on traffic lights or other signs that intend to urge caution and modern marketing techniques that make use of our reaction to shiny and flashy packaging. But, fortunately, the human mind exceeded the stage of pure stimuli-response and enabled conscious allocation of attention that allows a human decision maker to focus on (subjectively) important features of a task. An individual that plans to buy a new car, for example, usually decides which features are important, like the number of seats, engine technique, and maybe even color, and reduces the large amount of potential cars to the ones that meet those requirements. A large and still increasing amount of articles analyze the impact of limited attention in economic contexts.[1]

This cumulative dissertation contains three articles that investigate the economic consequences of those two different forms of the allocation of attention in industrial organization models and identifies financial constraints as one determining factor for the allocation of attention from experimental data.

The first article *Salience on E-Marketplaces as a Strategic Element in Vertical Product Differentiation* is based on the findings that attention is not always allocated actively, but can also be drawn automatically due to specific features of the environment. In this model, two firms compete with vertically differentiated products on two markets: an online e-marketplace as well as a "classical" market, where consumers buy the goods directly from the firms. The e-marketplace offers the ability to direct the focus of the consumers towards the products' prices and/or qualities by making the attribute salient within the presentation of the available goods. Therefore, the share of consumers that uses the e-marketplace to search and buy one of the two vertically differentiated goods has an increased focus on the salient dimension. The article shows that the firms strategically use this feature of the e-marketplace, with consequences for the provision of quality, market prices and welfare.

The second article *Limited Perception and Price Discrimination in a Model of Horizontal Product Differentiation (joint work with Marc P. Saur and Stefanie Y. Schmitt)* includes an attention allocation process of consumers based on individual preferences for horizontally differentiated products in a Hotelling model. Consumers only perceive goods that are relatively close to their most preferred version. With two firms offering goods on this market, there exist different groups of consumers: Those that do not notice either good (as both offered alternatives are too different from the most preferred version), those that do only perceive one good, and those consumers that are aware of both alternatives in the market. We analyze how the limited perception of market alternatives and the ability of firms to price discriminate between the different groups of consumers influence the horizontal product differentiation, market prices, and welfare. We find that some level of limited perception can be beneficial for consumers, as it reduces product differentiation which results in decreased average prices, and consumer surplus as well as welfare are maximized under limited rather than full market perception.

[1]For an overview, see Gabaix (2019).

The third article in this cumulative dissertation, *Poverty and Limited Attention (joint work with Stefanie Y. Schmitt)*, adds to the literature that investigates determinants for the allocation of attention. Based on experimental data from the Innovation Sample of the German Socio-Economic Panel Study (SOEP-IS, Richter and Schupp, 2015; Goebel, Liebig, Richter, Schröder, Schupp, and Wenzig, 2020), we investigate whether the financial strain of poverty alters the allocation of attention. The data of an inattentional blindness experiment allow us to study two different types of attention: attention to unexpected events and the focus on a primary task. We find differences in the attention allocation between the rich and the poor individuals in the sample in line with the Load theory developed by Lavie and colleagues (Lavie and Tsal, 1994; Lavie, 1995; Lavie, Hirst, de Fockert, and Viding, 2004). Compared to the richer individuals in the sample, the poorer individuals are more likely to notice unexpected events while no evidence is given for a reduced focus on the primary task.

In sum, the articles included in this dissertation highlight economic implications of limited attention as well as the influence of the individual economic endowment on the allocation of attention. The model in Section 2 investigates how firms can make use of an attention drawing process to extract some rent from the consumers, as firms can strategically use the ability to decide on which attribute of a good the attention is focused on. In Section 3, we show that limited attention per se does not have to be harmful for consumers, as a restriction of the consideration set can have beneficial effects regarding the provision of horizontally differentiated products. Concluding, those articles show that the economic actor that is in charge of the allocation of attention process can benefit from this special form of market power. In addition, those articles find an influence of limited attention on economic outcomes. In contrast, the third article in Section 4 finds that the economic situation—here measured by the individuals income—can have an impact on the allocation of attention as well. Understanding this interrelation between the influence of limited and focused attention on markets as well as the impact of the economic status on cognitive processes of individual decision makers can help to design decision contexts that alleviate attention-based biases and provide support for welfare maximizing decision making.

2 Salience on E-Marketplaces as a Strategic Element in Vertical Product Differentiation

Markus G. Schlatterer

Abstract

This article investigates the influence of an e-marketplace on the provision of vertically differentiated products that are sold on an e-marketplace as well as directly from the firms to consumers. The e-marketplace offers the ability to increase the salience of either the quality or the price dimension of the products provided by two homogeneous firms. The paper shows that firms can make use of the e-marketplace and its capability to highlight specific product dimensions to increase profits at the expense of consumer surplus.

2.1 Introduction

Electronic Marketplaces have become an important channel for firms in the business-to-consumer sector, as a increasing share of consumers uses these kind of platforms to search and — even more relevantly — buy products. This article analyzes how e-marketplaces and their ability to direct the focus of consumers on either the price or the quality dimension of goods influences the behavior of firms in a model of vertical product differentiation, where the product is offered on the e-marketplace as well as directly from the firms to the consumers.

The term e-marketplace is mainly used for a specific kind of online sales platform. E-marketplace describes a two-sided online platform that serves as a virtual place for sellers and buyers to meet (Bakos, 1991). It can be seen as the 21st century version of a traditional, geographic marketplace. In contrast to other forms of online platforms, the e-marketplaces that are subject of this article do not provide additional, supply chain related services to sellers (e.g., storage and shipment of products or the processing of returns) or buyers (e.g., insure transactions) beyond the provision of a virtual place to present the offers for firms, view these for consumers, and provide the infrastructure for the contract between those parties in case of a match. If a good is sold via the e-marketplace, those platforms typically charge a proportional commission fee. Those fees typically range within 7-15%.[2]

In general, e-marketplaces allow the consumers to compare the goods of different firms more easily, as the products are presented in the same way compared to the different presentations that firms can choose on their direct selling channels. This fact, combined with the reduction of search costs for the perception of available alternatives, has mainly driven the assumption that e-marketplaces can increase the competition among firms as well as reduce the influence of biasing factors in decision making (Bakos, 1997; Brown and Goolsbee, 2002). Nonetheless, e-marketplaces can — or at least try to — influence consumers in their decision making process. This can, for example, take place by the standard ranking within the product search at the e-marketplace or by the information that are given in the overview of different products that are available. Often, the firms that offer their goods on the e-marketplace can influence this procedure by choosing between different options of how to be present with their own products. For example, many e-marketplaces offer firms the option to become some kind of ”premium seller” on the platform. Those sellers benefit from additional, promotional services that typically consist of higher visibility of the good itself or of highlighting specific attributes of the product. In the course of this work, I refer to this as the *salience mechanism*.

In this paper, this procedure is build into a model of vertical product differentiation. In such models, offered goods differ in the two dimensions of price and quality. The e-marketplace, on which two competing firms sell their good additionally to traditional direct selling, offers the ability to present those dimensions equally salient or highlight one of those. It is assumed that a fraction of consumers uses only the e-marketplace to seek and buy the products of the two firms and does not buy those alternatives on the direct selling channels, while the other fraction of potential buyers orders their products directly from the producers. Those consumers that use the e-marketplace can be influenced by the salience mechanism by overestimating the importance of the salient attribute, while the outside shoppers decide which alternative to buy purely based on the quality and price dimension of the goods. For example, assume that two holiday homes are offered at the same location by two competing providers. Those can be booked via an e-marketplace platform or directly on the providers own websites. Those vacation homes may differ in the quality (e.g., by including a private pool, gym, or simply the quality of the furniture) and/or price. On the e-marketplace, each provider can choose a standard presentation on the results page of searches for the location, or a special appearance. Those representations can highlight the quality-related aspects or the price. Consumers that are using the e-marketplace, therefore,

[2]E.g., at the Amazon Marketplace, the commission fee depends on the type of product and ranges between 7-15%; Booking.com takes 15% for the commission of hotel bookings; Lieferando, the german brand of Delivery Hero, takes 13% for food orders (if the restaurant takes care of delivery)

directly receive the highlighted information in the first place and might overestimate the (subjective) importance of this dimension in the comparison of the two alternatives at hand.

In terms of related literature, this paper can be located in the interface of two lines of research: It is highly related to models that analyze the impact of highlighting specific attributes of product for individual decision-making. Thereby, I follow Bordalo, Gennaioli, and Shleifer (2013) in defining this as the salience of a products attribute. They directly refer to the work of the psychologists Taylor and Thompson (1982) by defining salience and its effect as "[...] the phenomenon that when one's attention is differentially directed to one portion on the environment rather than to others, the information contained in that portion will receive disproportionate weighting in subsequent judgments" (Taylor and Thompson, 1982). Equivalently to the model of Bordalo, Gennaioli, and Shleifer (2013), the salient attribute receives an overvaluation in the decision making process of the consumers in this model. In this paper, the salience of an attribute (i.e. of the price or the quality) endogenously arises from the distance in the shaping of those attributes compared to a reference good. This reference good is defined by the average of products available for consideration. In Bordalo, Gennaioli, and Shleifer (2016), the authors analyze the impact of salience on the competition between two firms, as the decisions on quality and price endogenously define the salience of those attributes. They find that, dependent on the relation between marginal and average costs of quality, price salient and quality salient equilibria exist. Within this model, the two goods provided can differ in the salience of an attribute, that is, for one good the price is salient, while quality is the salient attribute for the other. In this point, I follow Köszegi and Szeidl (2013) in the logic that if one attribute is salient for one good, it is salient for the alternatives as well. Their model describes a decision-making process based on "focus-weighted utility" instead of classical consumption utility, which differs in an over- or undervaluation of (exogenously given) attributes. In this approach, the focus weights arise as a function that is increasing in the distance between the representations of the attributes for all products available. In addition, I follow Köszegi and Szeidl (2013) in the assumption that consumer surplus is given by the unweighted consumption utility instead of the biased decision utility. In contrast to Bordalo, Gennaioli, and Shleifer (2016) and Heidhues and Köszegi (2017), the e-marketplace plays a major role in the creation of salience of price or quality in this paper, as salience can exogenously be set at the e-marketplace, while the competing firms can strategically make use of this feature.

At this point, this article is related to the research on two-sided platforms. One prominent line of the literature in this field focuses on the competition between such platforms as well as the inherent role of network externalities on such two-sided markets (Rochet and Tirole, 2003; Armstrong, 2006a; Gabszewicz and Wauthy, 2014). In contrast to this research, the focus of this article lies purely on the impact of the e-marketplace as an additional selling channel with the ability to influence the salience of either the price or quality characteristic of a good on the provision of those attributes by two independent firms. In other words, how the existence of a platform influences the competition on one side of the market. Related to this question, Zang, Cao, and He (2019) analyze different contract schemes of an e-marketplace, i.e., revenue sharing vs fixed fees, and their effect on the price and quality decision of a single firm that only sells on the platform. Pu, Sun, and Shao (2020) and Tian, Vakharia, Tan, and Xu (2018) investigate the optimal selling strategy of a single firm, that is, under which conditions a manufacturer or seller should optimally use either an e-marketplace, a direct selling channel, or both. In Ryan, Sun, and Zhao (2012) the e-marketplace is owned by one of two competing firms. This firm can either offer the marketplace service to its' competitor or use it exclusively. Those three papers allow the firm(s) to endogenously decide on prices, but deal with a single, fixed quality good.

The paper of Cremer and Thisse (1994) on commodity taxation in a differentiated oligopoly relates to this work, as the specific forms of taxation work technically equivalent to the commission fee on the e-marketplace. In contrast to the taxes analyzed there, the commission fee is obviously only payed on sales on the e-marketplace. Nonetheless, the pure effect of a commission fee (in the absence of a salient characteristic) on qualities and prices is equal to the findings of Cremer and Thisse (1994) for a uniform ad valorem tax rate.

The following Section 2.2 introduces the theoretical model. Section 2.3 presents the results of the three-stage game between two competing firms, followed by the welfare implications of the equilibrium behavior of the firms in Section 2.4. Finally, Section 2.5 concludes.

2.2 Model

This model is based on a standard model of vertical product differentiation by Gabszewicz and Thisse (1979) and the approach to model preferences for quality developed by Mussa and Rosen (1978). Consumers (of mass 1) have an individual marginal willingness to pay for quality θ. This is individually and independently drawn from a uniform distribution on $[0, 1]$. Two firms compete for these consumers by choosing qualities and prices of their respective product. They simultaneously choose the quality $q_i \geq 0$ of the good they want to offer. Without a loss of generality, I denote the firm that produces the higher quality by H and the firm that produces the lower quality by L, i.e., $i \in \{H, L\}$, such that we have $q_H > q_L$.[3] After choosing quality, the firms

[3] Note that the case of $q_H = q_L$ is ignored, as this would induce Bertrand price competition between the two firms and result in zero profits for both. Thus this can not be an equilibrium.

simultaneously choose their prices $p_i \geq 0$ in order to maximize profits. As can be seen later on in Section 2.3.1, the price of the high quality firm strictly exceeds the price of the low quality firm, such that we have $p_H > p_L$.
The utility function of each consumer that buys product i is given by

$$U_\theta(i) = v + \theta q_i - p_i,$$

where v denotes the base utility from consumption of the good. One might refer to v as usefulness of the lowest quality version of the product. Assume that $v \geq 2$, as this ensures a fully covered market (i.e., all consumers prefer to buy exactly one unit of her preferred quality to not buy a good and receive a utility of 0). Whether a consumer prefers the high quality version q_H at price p_H or the low quality version q_L at price p_L depends on his individual and independent willingness to pay θ. The consumer that is indifferent between the two versions is characterized by

$$\hat{\theta} \equiv \frac{p_H - p_L}{q_H - q_L}.$$

All consumer with $\theta < \hat{\theta}$ prefer the low quality version q_L at price p_L; all consumers with $\theta > \hat{\theta}$ prefer the high quality version q_H at price p_H. Both firms face identical cost functions for producing quality $C(q_i) = c_Q q_i^2$ with $c_Q > 0$. Without loss of generality, marginal costs of producing a good of any quality are normalized to 0.
Furthermore, assume that consumers could buy the good on a well established e-marketplace or buy directly from the firms. Let $\alpha \in [0, 1]$ denote the exogenously given share of consumers that uses the e-marketplace and which is independent of qualities and prices. The e-marketplace charges a uniform, fixed proportional commission fee $\tau \in]0, \frac{1}{4}]$ on the price that consumers pay for purchases on the e-marketplace.[4]
Respectively, $1 - \alpha$ denotes the share of consumers that buy outside the platform. Within both fractions, the willingness to pay for quality θ is uniformly distributed on $[0, 1]$.
Therefore, the profit functions of both firms are given by

$$\begin{aligned} \pi_H(q_H, q_L, p_H, p_L) &= \alpha(1 - \hat{\theta})(1 - \tau)p_H + (1 - \alpha)(1 - \hat{\theta})p_H - c_Q q_H^2, \\ \pi_L(q_H, q_L, p_H, p_L) &= \alpha\hat{\theta}(1 - \tau)p_L + (1 - \alpha)\hat{\theta}p_L - c_Q q_L^2. \end{aligned}$$

Note that the case of $\alpha = 0$ captures the standard model of vertical product differentiation and will be referred to as a benchmark.
Additionally, the e-marketplace offers the ability to increase the salience of either the price or quality dimension of a product. Each firm can spend c_σ to increase the focus of

[4]The restriction of $\tau \leq \frac{1}{4}$ simplifies the analysis and helps to focus on most relevant settings from an applied perspective in the discussion of welfare effects in Section 2.4.

potential consumers on either the price or quality attribute. Ceteris paribus, this can increase the share of consumers a firm could serve on the e-marketplace dependent on the firms advantage on this dimension, i.e., whether the firm offers the higher quality or sells at a lower price. Let $\sigma \in]0,1]$ denote the efficiency of this salience mechanisms. That is, how strongly consumers can be induced to increase their attention on the respective attribute price or quality. The decision utilities of the e-marketplace consumers are then given by

$$\begin{aligned}
U_{\theta_N}(i) &= v + \theta q_i - p_i && \text{if no attribute is salient,}\\
U_{\theta_B}(i) &= v + (1+\sigma)\theta q_i - (1+\sigma)p_i && \text{if quality and price are salient,}\\
U_{\theta_Q}(i) &= v + (1+\sigma)\theta q_i - p_i && \text{if only quality is salient, or}\\
U_{\theta_P}(i) &= v + \theta q_i - (1+\sigma)p_i && \text{if only price is salient.}
\end{aligned}$$

Therefore, the indifferent consumer on the e-marketplace can differ from the indifferent consumer on the outside market, as

$$\begin{aligned}
\hat{\theta}_Q &= \frac{p_H - p_L}{(1+\sigma)(q_H - q_L)} = \frac{1}{(1+\sigma)}\hat{\theta} && \text{if only quality is salient,}\\
\hat{\theta}_P &= \frac{(1+\sigma)(p_H - p_L)}{(q_H - q_L)} = (1+\sigma)\hat{\theta} && \text{if only price is salient.}
\end{aligned}$$

If both firms decide to increase the salience of quality and price respectively, the effects cancel out, as consumers' focus is equally driven to both prices and qualities. If no attribute is salient, the indifferent consumer on the e-marketplace and the outside market equal in the individual marginal willingness to pay for quality, i.e., $\hat{\theta}_B = \hat{\theta}_N = \hat{\theta}$.

The timing of events is as follows:
First, both firms H and L observe the commission fee τ, the share of consumers that are only searching and buying products on the e-marketplace α and the effectiveness of increasing the salience of an attribute σ. Dependent on these parameters, the firms decide to offer their product on the e-marketplace with or without the ability to increase the salience of either price or quality.
Second, the firms simultaneously and independently choose the qualities q_H and q_L.
Third, both firms simultaneously and independently decide on the prices p_H and p_L.
Finally, each consumer buys exactly one unit of his preferred alternative, while the e-marketplace receives its commission fee for the products that are sold via this channel. The decisions on qualities and prices depend on the decision in the first (salience) stage of the game. Therefore, the profits for the different cases of salience are given below. Note that the costs of increasing the salience of an attribute c_σ are treated as sunk costs for the maximization problem over quality and price in the second and third stage

of the game and, therefore, are ignored here.
The profit of firm H for different salient attributes can then be described as

$$
\begin{aligned}
\pi_H^N(q_H,q_L,p_H,p_L) &= \alpha(1-\hat{\theta})(1-\tau)p_H + (1-\alpha)(1-\hat{\theta})p_H - c_Q q_H^2 && \text{if no attribute is salient,}\\
\pi_H^B(q_H,q_L,p_H,p_L) &= \alpha(1-\hat{\theta})(1-\tau)p_H + (1-\alpha)(1-\hat{\theta})p_H - c_Q q_H^2 && \text{if quality \& price are salient,}\\
\pi_H^Q(q_H,q_L,p_H,p_L) &= \alpha(1-\hat{\theta}_Q)(1-\tau)p_H + (1-\alpha)(1-\hat{\theta})p_H - c_Q q_H^2 && \text{if only quality is salient,}\\
\pi_H^P(q_H,q_L,p_H,p_L) &= \alpha(1-\hat{\theta}_P)(1-\tau)p_H + (1-\alpha)(1-\hat{\theta})p_H - c_Q q_H^2 && \text{if only price is salient.}
\end{aligned}
$$

Respectively, the profit of firm L is given by

$$
\begin{aligned}
\pi_L^N(q_H,q_L,p_H,p_L) &= \alpha(\hat{\theta})(1-\tau)p_L + (1-\alpha)(\hat{\theta})p_L - c_Q q_L^2 && \text{if no attribute is salient,}\\
\pi_L^B(q_H,q_L,p_H,p_L) &= \alpha(\hat{\theta})(1-\tau)p_L + (1-\alpha)(\hat{\theta})p_L - c_Q q_L^2 && \text{if quality \& price are salient,}\\
\pi_L^Q(q_H,q_L,p_H,p_L) &= \alpha(\hat{\theta}_Q)(1-\tau)p_L + (1-\alpha)(\hat{\theta})p_L - c_Q q_L^2 && \text{if only quality is salient,}\\
\pi_L^P(q_H,q_L,p_H,p_L) &= \alpha(\hat{\theta}_P)(1-\tau)p_L + (1-\alpha)(\hat{\theta})p_L - c_Q q_L^2 && \text{if only price is salient.}
\end{aligned}
$$

2.3 Results

The game described above is solved by backward induction. In a first step, it is solved for the pure strategy equilibria within the third (price setting) stage and the second (quality setting) stage of the game for the different decisions of either firm in the first (salience) stage of the game. Subsection 2.3.2, then, describes the pure strategy equilibria within this first (salience) stage to define the subgame-perfect equilibrium of the game.

2.3.1 Equilibria in the quality and price setting stages

The optimal prices and qualities of both firms can be derived from the respective profit function taken the different decisions in the (first) salience stage as given. Note that we can ignore the fixed costs for making an attribute salient at this point, since once we reach this subgames, these fixed costs do not influence the optimal choice in the price and quality setting stages. Those fixed costs c_σ are included in the analysis of the first (salience) stage that follows in subsection 2.3.2.

No attribute salient

If neither the quality nor the price is salient, the profit function of firm H is given by

$$\pi_H^N(q_H^N, q_L^N, p_H^N, p_L^N) = \alpha\left(1 - \frac{p_H^N - p_L^N}{q_H^N - q_L^N}\right)(1-\tau)p_H^N + (1-\alpha)\left(1 - \frac{p_H^N - p_L^N}{q_H^N - q_L^N}\right)p_H^N - c_Q {q_H^N}^2$$

and of firm L by

$$\pi_L^N(q_H^N, q_L^N, p_H^N, p_L^N) = \alpha\left(\frac{p_H^N - p_L^N}{q_H^N - q_L^N}\right)(1-\tau)p_L^N + (1-\alpha)\left(\frac{p_H^N - p_L^N}{q_H^N - q_L^N}\right)p_L^N - c_Q {q_L^N}^2.$$

The first order conditions for optimal prices yield the best reply functions

$$p_H^N(p_L^N) = \frac{p_L^N + q_H^N - q_L^N}{2} \quad \text{and} \quad p_L^N(p_H^N) = \frac{p_H^N}{2}.$$

Equilibrium prices for this case are therefore given by

$$p_H^N = \frac{2(q_H^N - q_L^N)}{3} \quad \text{and} \quad p_L^N = \frac{q_H^N - q_L^N}{3}.$$

Using these equilibrium prices, the first derivatives with respect to the quality of the respective profit functions of firm H and form L are given by

$$\begin{aligned}\frac{\partial \pi_H^N}{\partial q_H^N} &= \frac{2}{9}(2 - 9\ c_Q\ q_H^N - 2\alpha\tau),\\ \frac{\partial \pi_L^N}{\partial q_L^N} &= -\frac{1}{9}(1 + 18\ c_Q\ q_L^N - \alpha\tau).\end{aligned}$$

While the profit of firm H is initially increasing in the quality q_H^N and results in a positive optimal quality for firm H, the profit of firm L is strictly decreasing in q_L^N. Therefore, the low quality firm L prefers to offer the lowest quality possible, i.e. a corner solution is given for firm L's optimal quality decision. Building the first order conditions for maximum profits, the optimal quality decisions are given by

$$\begin{aligned}q_H^N &= \frac{2(1-\alpha\tau)}{9c_Q},\\ q_L^N &= 0.\end{aligned}$$

Thus, the equilibrium prices and qualities without a salient attribute are given by

$$\begin{aligned}q_H^N = \frac{2(1-\alpha\tau)}{9c_Q} \quad &\text{with} \quad p_H^N = \frac{4(1-\alpha\tau)}{27c_Q},\\ q_L^N = 0 \quad &\text{with} \quad p_L^N = \frac{2(1-\alpha\tau)}{27c_Q},\end{aligned}$$

and yielding equilibrium profits of firm H and firm L by

$$\pi_H^N = \frac{4(1-\alpha\tau)^2}{81c_Q},$$
$$\pi_L^N = \frac{2(1-\alpha\tau)^2}{81c_Q}.$$

Both attributes salient

If both attributes are salient, the pure strategy equilibrium in the price and the quality stage of the game remain unchanged compared to the situation of no attribute being salient, as the Nash equilibria in the quality and price setting stage are given in the absence of the costs for increasing the salience of a specific attribute at this point. Therefore, we have

$$q_H^B = \frac{2(1-\alpha\tau)}{9c_Q} \quad ; \quad p_H^B = \frac{4(1-\alpha\tau)}{27c_Q} \quad ; \quad \pi_H^B = \frac{4(1-\alpha\tau)^2}{81c_Q}$$
$$q_L^B = 0 \quad ; \quad p_L^B = \frac{2(1-\alpha\tau)}{27c} \quad ; \quad \pi_L^B = \frac{2(1-\alpha\tau)^2}{81c_Q}$$

Only quality salient

If only quality is the salient attribute of the good, the profit of firm H is given by

$$\pi_H^Q(q_H^Q, q_L^Q, p_H^Q, p_L^Q) = \alpha\left(1 - \frac{p_H^Q - p_L^Q}{(1+\sigma)(q_H^Q - q_L^Q)}\right)(1-\tau)p_H^Q + (1-\alpha)\left(1 - \frac{p_H^Q - p_L^Q}{q_H^Q - q_L^Q}\right)p_H^Q - c_Q {q_H^Q}^2$$

and for firm L by

$$\pi_L^Q(q_H^Q, q_L^Q, p_H^Q, p_L^Q) = \alpha\left(\frac{p_H^Q - p_L^Q}{(1+\sigma)(q_H^Q - q_L^Q)}\right)(1-\tau)p_L^Q + (1-\alpha)\left(\frac{p_H^Q - p_L^Q}{q_H^Q - q_L^Q}\right)p_L^Q - c_Q {q_L^Q}^2.$$

The best reply functions for optimal prices and given levels of q_H^Q and q_L^Q are given by

$$p_H^Q(p_L^Q) = \frac{1}{2}\left(p_L^Q + \frac{(q_H^Q - q_L^Q)(1+\sigma)(1-\alpha\tau)}{1+\sigma(1-\alpha)-\alpha\tau}\right) \quad \text{and} \quad p_L^Q(p_H^Q) = \frac{p_H^Q}{2}$$

and yield the following equilibrium in the price stage for this case:

$$p_H^Q = \frac{2(q_H^Q - q_L^Q)(1+\sigma)(1-\alpha\tau)}{3(1+\sigma(1-\alpha)-\alpha\tau)} \quad \text{and} \quad p_L^Q = \frac{(q_H^Q - q_L^Q)(1+\sigma)(1-\alpha\tau)}{3(1+\sigma(1-\alpha)-\alpha\tau)}.$$

Taking the first derivatives of the profit functions for the optimal decision in the price setting stage

$$\frac{\partial \pi_H^Q}{\partial q_H^Q} = \frac{4(1+\sigma)(1-\alpha\tau)^2}{9(1+\sigma(1-\alpha)-\alpha\tau)} - 2\ c_Q\ q_H^Q,$$
$$\frac{\partial \pi_L^Q}{\partial q_L^Q} = -\frac{(1+\sigma)(1-\alpha\tau)^2}{9(1+\sigma(1-\alpha)-\alpha\tau)} - 2\ c_Q\ q_L^Q$$

yields a strictly negative effect of producing quality for the low quality firm L. Thus it prefers to produce the lowest quality possible as a corner solution. The first order condition for the optimal choice in the second (quality setting) stage for firm H yields

$$q_H^Q = \frac{2(1+\sigma)(1-\alpha\tau)^2}{9c_Q(1+\sigma(1-\alpha)-\alpha\tau)}$$
$$q_L^Q = 0.$$

The equilibrium qualities and prices in the case of salient quality are therefore given by

$$q_H^Q = \frac{2(1+\sigma)(1-\alpha\tau)^2}{9c_Q(1+\sigma(1-\alpha)-\alpha\tau)} \quad \text{with} \quad p_H^Q = \frac{4(1+\sigma)^2(1-\alpha\tau)^3}{27c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}$$
$$q_L^Q = 0 \quad \text{with} \quad p_L^Q = \frac{2(1+\sigma)^2(1-\alpha\tau)^3}{27c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}$$

with profits of firm H and firm L:

$$\pi_H^Q = \frac{4(1+\sigma)^2(1-\alpha\tau)^4}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2},$$
$$\pi_L^Q = \frac{2(1+\sigma)^2(1-\alpha\tau)^4}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}.$$

Note that, up to this point, I did not include the costs of increasing the salience of quality c_σ that has to be taken by one of both firms in order to make quality salient. If firm H increases the salience of quality, we have $\pi_H^Q - c_\sigma$. If firm L increases the salience of quality, we have $\pi_L^Q - c_\sigma$.

Only price salient

Equivalently to the previous case, I can describe the equilibrium for the price and the quality stage if the price is the only salient attribute of the good while, again, ignoring the fixed costs c_σ for increasing the salience at this point.

The profit functions of firm H and firm L for a salient price are given by

$$\pi_H^P(q_H^P, q_L^P, p_H^P, p_L^P) = \alpha \left(1 - \frac{(1+\sigma)(p_H^P - p_L^P)}{q_H^P - q_L^P}\right)(1-\tau)p_H^P + (1-\alpha)\left(1 - \frac{p_H^P - p_L^P}{q_H^P - q_L^P}\right)p_H^P - c_Q {q_H^P}^2,$$
$$\pi_L^P(q_H^P, q_L^P, p_H^P, p_L^P) = \alpha \left(\frac{(1+\sigma)(p_H^P - p_L^P)}{q_H^P - q_L^P}\right)(1-\tau)p_L^P + (1-\alpha)\left(\frac{p_H^P - p_L^P}{q_H^P - q_L^P}\right)p_L^P - c_Q {q_L^P}^2.$$

From the best reply functions derived from those profits and given levels of q_H^P and q_L^P

$$p_H^P(p_L^P) = \frac{q_H^P - q_L^P + p_L^P(1+\alpha\sigma) - \alpha\tau(q_H^P - q_L^P + p_L^P(1+\sigma))}{2 - 2\alpha(\sigma\tau - \sigma + \tau)} \quad \text{and} \quad p_L^P(p_H^P) = \frac{p_H^P}{2}$$

follows the equilibrium in the price stage:

$$p_H^P = \frac{2(q_H^P - q_L^P)(1-\alpha\tau)}{3 - 3\alpha(\sigma\tau - \sigma + \tau)} \quad \text{and} \quad p_L^P = \frac{(q_H^P - q_L^P)(1-\alpha\tau)}{3 - 3\alpha(\sigma\tau - \sigma + \tau)}.$$

The first derivatives of the profit functions with given prices and the optimal qualities of firm H and firm L — with a corner solution due to the decrease of profit in q_L^P — are then given by

$$\frac{\partial \pi_H^P}{\partial q_H^P} = \frac{4(1-\alpha\tau)^2}{9 - 9\alpha(\sigma\tau - \sigma + \tau)} - 2\, c_Q\, q_H^P$$
$$\frac{\partial \pi_L^P}{\partial q_L^P} = -\frac{(1-\alpha\tau)^2}{9 - 9\alpha(\sigma\tau - \sigma + \tau)} - 2\, c_Q\, q_L^P$$

$$q_H^P = \frac{2(1-\alpha\tau)^2}{9c_Q(1 - \alpha(\sigma\tau - \sigma + \tau)}$$
$$q_L^P = 0.$$

and yield the equilibrium for the price and quality stage

$$q_H^P = \frac{2(1-\alpha\tau)^2}{9c_Q(1 - \alpha(\sigma\tau - \sigma + \tau)} \quad \text{with} \quad p_H^P = \frac{4(1-\alpha\tau)^3}{27c_Q(1 - \alpha(\sigma\tau - \sigma + \tau))^2}$$
$$q_L^P = 0 \quad \text{with} \quad p_L^P = \frac{2(1-\alpha\tau)^3}{27c_Q(1 - \alpha(\sigma\tau - \sigma + \tau))^2}$$

with profits of firm H and firm L given by

$$\pi_H^P = \frac{4(1-\alpha\tau)^4}{81c_Q(1-\alpha(\sigma\tau-\sigma+\tau))^2}$$
$$\pi_L^P = \frac{2(1-\alpha\tau)^4}{81c_Q(1-\alpha(\sigma\tau-\sigma+\tau))^2}.$$

As in the previous case of salient quality, I did not include the costs of increasing the salience c_σ that has to be taken by one of both firms to this point. If firm H increases the salience of the price, we have $\pi_H^P - c_\sigma$. If firm L increases the salience of the price, we have $\pi_L^P - c_\sigma$.

Benchmark Case

Note that for $\alpha = 0$, all cases correspond to the benchmark (BM) equilibrium without the existence of an e-marketplace, i.e., the result of a standard vertical product differentiation model. Equilibrium prices, qualities, and profits are then given by:

$$q_H^{BM} = \frac{2}{9c_Q} \quad ; \quad p_H^{BM} = \frac{4}{27c_Q} \quad ; \quad \pi_H^{BM} = \frac{4}{81c_Q}$$
$$q_L^{BM} = 0 \quad ; \quad p_L^{BM} = \frac{2}{27c_Q} \quad ; \quad \pi_L^{BM} = \frac{2}{81c_Q}.$$

2.3.2 Salience game

The first (salience) stage of the game can be described as a 3x3 normal form game, in which the actions of both firms $i \in \{H, L\}$ are given by $A_i = \{N, Q, P\}$. Action N describes that the firm does not pay the e-marketplace to increase the salience of any attribute, action Q corresponds with an increase of the salience of the quality, and action P with an increase of salience of the price. The strategies of both firms for the three stage game are then given by $s_i = (A_i, q_i^j, p_i^j)$ with $j = \{N, B, Q, P\}$.

		Firm L: N	Firm L: Q	Firm L: P
Firm H	N	π_H^N , π_L^N	π_H^Q , $\pi_L^Q - c_\sigma$	π_H^P , $\pi_L^P - c_\sigma$
	Q	$\pi_H^Q - c_\sigma$, π_L^Q	$\pi_H^Q - c_\sigma$, $\pi_L^Q - c_\sigma$	$\pi_H^B - c_\sigma$, $\pi_L^B - c_\sigma$
	P	$\pi_H^P - c_\sigma$, π_L^P	$\pi_H^B - c_\sigma$, $\pi_L^B - c_\sigma$	$\pi_H^P - c_\sigma$, $\pi_L^P - c_\sigma$

As described above, if one firm makes use of the platforms capability to increase the salience of one attribute by paying the costs c_σ to do so, this not only affects that firm, but also the competitor on the e-marketplace, as all e-marketplace consumers increase the focus on the salient dimension. If both firms invest into different salience strategies, i.e. one highlights the quality and the other firm highlights the price, the effect cancels out.

The Nash equilibria of the subgames given for the different salient attributes contain the well described features of a vertical differentiation model. Within these models, the quality dimension is strategically used to differentiate the goods of the firms and, therefore, reduce the price competition among those firms. As firm L always prefers to produce the lowest quality possible which results in a corner solution of $q_L^j = 0 \;\forall\; j \in \{N, B, Q, P\}$, firm H's quality decision depends on which attribute is salient. For the given ranges of parameters,[5] we have $q_H^Q > q_H^N = q_H^B > q_H^P$, resulting in prices $p_i^Q > p_i^N = p_i^B > p_i^P$. This is driven by the increased differentiation between the products due to salient quality and its' effect on reduced price competition among the firms. Salient prices would have an opposite effect, as the high quality firm reacts to this situation with a reduced quality and thus increased price competition.

Taking profits in the absence of salience costs c_σ, the optimal decisions on qualities and prices yield $\pi_i^Q > \pi_i^N = \pi_i^B > \pi_i^P$, i.e., both firms prefer salient quality, reasoned in the increased product differentiation and reduced price competition. Firm H does react with an increase in quality, gaining additional demand on the e-marketplace — as $\hat{\theta}_Q$ is decreasing in α — combined with an increased price of its product. Additionally, the quality-price ratio $\frac{q_H^Q}{p_H^Q}$ is strictly decreasing in α, whereas it is constant when no attribute is salient (see Section 2.4 for more details). Even though firm L loses some fraction of consumers on the e-marketplace compared to the outside market or the situation of none or both attributes being salient, i.e. $\hat{\theta}_Q < \hat{\theta}$, the increase in price yields a higher profit for firm L in total as well.

When the e-marketplace charges costs $c_\sigma > 0$ for the increase of salience, firstly, we find $\pi_i^N > \pi_i^B - c_\sigma > \pi_i^P - c_\sigma$. Therefore, contrary attempts to increase the salience of price and quality as well as an increase of salience of the price can not be an equilibrium. Making both attributes salient is only costly for the firms without an effect on the decision making of consumers. Therefore, this is dominated by not investing in salience of either dimension for both firms. An increased salience of the price is even more harmful for both firms, as the increased price competition leads to lower profits for both firms. Secondly, one can find that firm H invests in salient quality given that the

[5] i.e. $c_Q > 0$; $\alpha \in [0,1]$; $\tau \in]0, \frac{1}{4}]$; $\sigma \in]0,1]$

other firm has not invested in the increase of salience of quality if

$$\pi_H^Q - c_\sigma \geq \pi_H^N$$
$$\frac{4(1+\sigma)^2(1-\alpha\tau)^4}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2} - c_\sigma \geq \frac{4(1-\alpha\tau)^2}{81c_Q}$$
$$c_\sigma \leq \frac{4\alpha\sigma(1-\tau)(1-\alpha\tau)^2(2+\sigma(2-\alpha)-\alpha\tau(2+\sigma))}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}$$

Equivalently, firm L has an incentive to increase the salience of quality if

$$\pi_L^Q - c_\sigma \geq \pi_L^N$$
$$\frac{2(1+\sigma)^2(1-\alpha\tau)^4}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2} - c_\sigma \geq \frac{2(1-\alpha\tau)^2}{81c_Q}$$
$$c_\sigma \leq \frac{2\alpha\sigma(1-\tau)(1-\alpha\tau)^2(2+\sigma(2-\alpha)-\alpha\tau(2+\sigma))}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}$$

Obviously, both firms profit can benefit from an increased salience of quality initiated by the competitor, such that the firms face a public good problem with the increase of salience. Proposition 1 characterizes the subgame-perfect equilibria in pure strategies for all values of $\alpha > 0$, as the case of $\alpha = 0$ reflects the standard case of vertical product differentiation that I will refer to as benchmark in the welfare analysis.

Proposition 1 *Characterization of the subgame-perfect equilibria in pure strategies for all* $\alpha > 0$*:*

(i) For $0 < c_\sigma \leq \frac{2\alpha\sigma(1-\tau)(1-\alpha\tau)^2(2+\sigma(2-\alpha)-\alpha\tau(2+\sigma))}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}$*, there exist two subgame-perfect equilibria in pure strategies:* $((Q, q_H^Q, p_H^Q), (N, q_L^Q, p_L^Q))$ *and* $((N, q_H^Q, p_H^Q), (Q, q_L^Q, p_L^Q))$*, where either firm H or firm L increases the salience of quality.*

(ii) For $\frac{2\alpha\sigma(1-\tau)(1-\alpha\tau)^2(2+\sigma(2-\alpha)-\alpha\tau(2+\sigma))}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2} < c_\sigma \leq \frac{4\alpha\sigma(1-\tau)(1-\alpha\tau)^2(2+\sigma(2-\alpha)-\alpha\tau(2+\sigma))}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}$*, there exists a unique subgame-perfect equilibrium in pure strategies:* $((Q, q_H^Q, p_H^Q), (N, q_L^Q, p_L^Q))$*, where firm H increases the salience of quality.*

(iii) For $c_\sigma > \frac{4\alpha\sigma(1-\tau)(1-\alpha\tau)^2(2+\sigma(2-\alpha)-\alpha\tau(2+\sigma))}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}$*, there exists a unique subgame-perfect equilibrium in pure strategies:* $((N, q_H^N, p_H^N), (N, q_L^N, p_L^N))$*, where no attribute is salient.*

As long as c_σ is sufficiently small, both firms benefit from salient quality on the e-marketplace. Hence, competition under salient quality forms the subgame-perfect equilibrium in this case, where one of the two firms in the market invests in the increase of salience of quality. If the costs of the e-marketplace for making quality salient are larger, only the high quality firms' increase in profit due to salient quality allow to invest in the salience. Nonetheless, both firms profit from the investment. If the costs c_σ become to large, the firms prefer competition without a salient attribute.

2.4 Welfare analysis

In this section, the consequences of the resulting equilibria for consumers, firms and the total welfare is analyzed. As mentioned above, the resulting equlibira will be compared to the standard benchmark case without the existence of an e-marketplace, i.e. $\alpha = 0$. The consumer surplus can be split into the surplus of those consumers buying the high quality good and those consumers buying the low quality good. It is fruitful to analyze the consequences for those groups separately. Generally, consumer surplus and total welfare can be described as

$$\begin{aligned}
CS^j &= CS^j_H + CS^j_L \\
CS^j &= \alpha \int_{\hat{\theta}_j}^{1} v + \theta q^j_H - p^j_H \, d\theta + (1-\alpha) \int_{\hat{\theta}}^{1} v + \theta q^j_H - p^j_H \, d\theta \\
&\quad + \alpha \int_{0}^{\hat{\theta}_j} v + \theta q^j_L - p^j_L \, d\theta + (1-\alpha) \int_{0}^{\hat{\theta}} v + \theta q^j_L - p^j_L \, d\theta \\
W^j &= CS^j + \pi^j_H + \pi^j_L + \pi^j_P.
\end{aligned}$$

If no attribute is salient, the e-marketplace earns profits from the proportional commission fee τ from both the high and low quality good sold via this channel. This is given by

$$\begin{aligned}
\pi^N_P &= \alpha \left(1 - \hat{\theta}\right) \tau p^N_H + \alpha \hat{\theta} \tau p^N_L \\
&= \frac{5\alpha\tau(2 - 2\alpha\tau)}{81 c_Q}.
\end{aligned}$$

If no attribute is salient, those are given by:

$$\begin{aligned}
CS^N_H &= \frac{2}{3} v \\
CS^N_L &= \frac{1}{3} v - \frac{2(1-\alpha\tau)}{81 c_Q} \\
CS^N &= v - \frac{2(1-\alpha\tau)}{81 c_Q} \\
W^N &= v + \frac{4(1-\alpha^2\tau^2)}{81 c_Q}.
\end{aligned}$$

In this case, firm H produces quality $q^N_H = \frac{2(1-\alpha\tau)}{9c_Q}$, which is strictly decreasing in α

and τ. The vertical differentiation between the two goods is therefore decreasing in the market share of the e-marketplace, resulting in an increase of price competition between the firms and consequently lower prices for both high and low quality consumers. The increase of consumer surplus in α is, however, purely driven by the gains of low quality consumers, as the high quality consumers suffer from the reduced quality offered. This group faces the same consumer surplus as in the benchmark situation without an e-marketplace, as the quality-price-ratio of the high quality product is constant for all $\alpha \in [0,1]$, as

$$\frac{q_H^N}{p_H^N} = \frac{\frac{2(1-\alpha\tau)}{9c_Q}}{\frac{4(1-\alpha\tau)}{27c_Q}} = \frac{3}{2}.$$

The profit of firm H, π_H^N, as well as the profit of firm L, π_L^N, are both strictly decreasing in α, due to increased price competition and a larger fraction of sales on the e-marketplace, for which the commission fee τ has to be payed. The sum of these loses exceeds the sum of gains of the e-marketplace from an increased amount of sales via their channel and the gains in surplus of low quality consumers, resulting in a decrease of total welfare W^N in α. Compared to the benchmark (with $W^{BM} = v + \frac{4}{81c_Q}$), the total welfare is always smaller if a fraction of consumers can only be reached via the e-marketplace with no attribute salient.

If one firm takes the costs c_σ to increase the salience of quality, the profit of the e-marketplace is given by

$$\begin{aligned}\pi_P^Q &= \alpha\left(1-\hat{\theta}_Q\right)\tau p_H^Q + \alpha\hat{\theta}_Q\tau p_L^Q + c_\sigma \\ &= \frac{2\alpha\tau(1+\sigma)^2(1-\alpha\tau)^3(5+6\sigma(1-\alpha)-5\alpha\tau)}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^3} + c_\sigma,\end{aligned}$$

such that in the case of salient quality, consumer surplus and welfare are given by:

$$CS_H^Q = \frac{1}{3}v\frac{(\sigma(1-\alpha)(\alpha\tau+2)-2\alpha\tau+2)}{(1+\sigma(1-\alpha)-\alpha\tau)} - \frac{\alpha\sigma(\sigma+1)(1-\alpha\tau)^2(2(1-\alpha\tau)(4-(\alpha+3)\tau)-3\sigma(1-\alpha)(\tau(\alpha\tau+2)-3))}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^3}$$

$$CS_L^Q = \frac{1}{3}v\frac{(1+\sigma-\alpha\sigma)(1-\alpha\tau)}{(1+\sigma(1-\alpha)-\alpha\tau)} - \frac{2(1+\sigma)^2(1+\sigma(1-\alpha)(1-\alpha\tau)^4}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^3}$$

$$CS^Q = v - \frac{(1+\sigma)(1-\alpha\tau)^2[2(1-\alpha\tau)^2+2\sigma(1-\alpha\tau)(2-\alpha(5\tau-3))+\sigma^2(1-\alpha)(2-\alpha(\tau(10+\alpha\tau)-9))]}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^3}$$

$$W^Q = v - \frac{(1+\sigma)(1-\alpha\tau)^2[4(1-\alpha\tau)^2(1+\alpha\tau)+\sigma^2(1-\alpha)(4-\alpha(9-5\tau(2-\alpha\tau)))+2\sigma(1-\alpha\tau)(4-\alpha(6+\tau(\alpha(3+2\tau)-7)))]}{81c_Q(1+\sigma(1-\alpha)-\alpha\tau)^3}$$

Firm H produces the quality $q_H^Q = \frac{2(1+\sigma)(1-\alpha\tau)^2}{9c_Q(1+\sigma(1-\alpha)-\alpha\tau)}$, that is strictly decreasing in the exogenous commission fee τ and strictly increasing in the salience parameter σ. Analyzing the first derivative of the quality q_H^Q with respect to the market share of the e-marketplace

$$\frac{\partial q_H^Q}{\partial \alpha} = \frac{2(1+\sigma)(1-\alpha\tau)(\sigma-(2-\alpha)\sigma\tau-(1-\alpha\tau)\tau)}{9c_Q(1+\sigma(1-\alpha)-\alpha\tau)^2}$$

yields that the effect of α on the quality of firm H depends on the relation of τ and σ. q_H^Q is strictly increasing in α $\forall$ $\sigma \geq \frac{\tau}{1-2\tau}$. That is, if the salience effect is sufficiently strong, firm H increases the quality of the product even for small fractions of consumers using the e-marketplace and, hence, are influenced by the salience mechanism. For $\tau < \sigma < \frac{\tau}{1-2\tau}$, the quality q_H^Q is only increasing if the market share of the e-marketplace is sufficiently large, i.e., $\alpha > \frac{2(1+\sigma)}{\sigma+\tau} - \frac{1}{\tau}$. The high quality firm does only increase the quality if a sufficiently large fraction of consumers is influenced by the salience mechanism. If $\sigma < \tau$, the quality of firm H is strictly decreasing in α, even in the case of salient quality.
As mentioned above, we have $q_H^Q > q_H^N$ $\forall$ $\sigma > 0$ and fixed levels of α and τ. Therefore, the differentiation between the two available products is larger and results in reduced price competition with higher prices for both the high and low quality product for salient quality compared to the situation of no attribute being salient on the e-marketplace. While it is straightforward to see that the low quality consumers only suffer from the increased price while facing minimum quality $q_L^Q = 0$ (and, therefore, $CS_L^Q < CS_L^N$), the high quality consumers gain from an higher quality offered compared to the case of no attribute being salient. Nonetheless, focusing on the quality-price-ratio of the high quality good in this case, i.e.,

$$\frac{q_H^Q}{p_H^Q} = \frac{3}{2}\frac{(1+\sigma(1-\alpha)-\alpha\tau)}{(1+\sigma)(1-\alpha\tau)},$$

first derivatives with respect to τ, σ and α show that

$$\begin{aligned}
\frac{\partial \frac{q_H^Q}{p_H^Q}}{\partial \tau} &= \frac{3}{2}\frac{\alpha\sigma(1-\alpha)}{(1+\sigma)(1-\alpha\tau)^2} > 0,\\
\frac{\partial \frac{q_H^Q}{p_H^Q}}{\partial \sigma} &= -\frac{3}{2}\frac{\alpha(1-\tau)}{(1+\sigma)^2(1-\alpha\tau)} < 0,\\
\frac{\partial \frac{q_H^Q}{p_H^Q}}{\partial \alpha} &= -\frac{3}{2}\frac{\sigma(1-\tau)}{(1+\sigma)(1-\alpha\tau)^2} < 0.
\end{aligned}$$

The quality-price-ratio for the high quality good is increasing in the commission fee τ (due to the decrease of q_H^Q in τ), and strictly decreasing in the salience of quality σ and the market share of the e-marketplace α, as the relative increase in price exceeds the relative increase of quality for the high quality product compared. But one can find that, even with a decreasing quality-price-ratio, high quality consumers can benefit from salient quality, as it can be shown that

$$CS_H^Q > CS_H^N \quad \text{if}$$
$$c_Q > \frac{(1+\sigma)(1-\alpha\tau)^2(3\sigma(1-\alpha)(3-\tau(2+\alpha\tau))+2(1-\alpha\tau)(4-(3+\alpha)\tau))}{27v(1-\alpha)\tau(1+\sigma(1-\alpha)-\alpha\tau)^2}.$$

That is, if the costs of producing quality are sufficiently large, high quality consumers benefit from an increase in quality due to the increased salience of the quality dimension. Without the effect of salient quality, the high quality firm H would produce a quality too low for the fraction of consumers with a high individual willingness to pay for quality θ. Nonetheless, taking all consumers into account, $CS^Q < CS^N$ for the entire range of parameters, as the loss in surplus due to increased prices strictly exceeds the gains from a quality increase for the high quality consumers, even in the case of high quality costs c_Q. Therefore, an increased focus of consumers on quality due to the salience of this attribute on the e-marketplace is harmful for consumers.

To analyze the effect of salient quality on total welfare, it is fruitful to separately focus on the profits of the two firms and the e-marketplace. Both firms H and L only benefit from an increased market share of the e-marketplace in the case of salient quality if the vertical differentiation of their products increases in α. As mentioned above, this is only the case if the salience parameter σ is sufficiently large compared to the commission fee τ, i.e. $\sigma \geq \frac{\tau}{1-2\tau} \quad \vee \quad \tau < \sigma < \frac{\tau}{1-2\tau} \ \wedge \ \alpha > \frac{2(1+\sigma)}{\sigma+\tau} - \frac{1}{\tau}$.

For this range of parameters, both firms can achieve higher profits than in the benchmark case without the existence of the e-marketplace if they don't face costs for increasing the salience c_σ. Such costs transfer a fraction of profit from one firm to the e-marketplace and are, therefore, irrelevant in terms of total welfare. Obviously, the e-marketplace strictly benefits from an increased number of sales on its' platform.

Whether the total welfare is increasing or decreasing in α does depend on whether the gains of the e-marketplace and of the firms exceed the losses in consumer surplus. There exists a range of parameters for which the total welfare W^Q is increasing in α, i.e.

$$\frac{\partial W^Q}{\partial \alpha} > 0 \ \forall \ \sigma < \frac{2\tau}{1-2\tau} \ \wedge \ \alpha < \hat{\alpha}$$

As the second derivative $\frac{\partial^2 W^Q}{\partial^2 \alpha} < 0$ for this relation of σ and τ, a welfare maximum is given at $\hat{\alpha} = \arg\max_\alpha W^Q$. The following Figure 1 shows the development of $\hat{\alpha}$ in σ for different commission fee levels τ. This share is first increasing in σ, as the gains of both the firms and the platform exceed the losses in consumer surplus. This relation does change in the course of an increasing σ, until the losses in consumer surplus exceed for all $\sigma > \frac{2\tau}{1-2\tau}$, for which the existence of the e-marketplace with salient quality is harmful for total welfare.

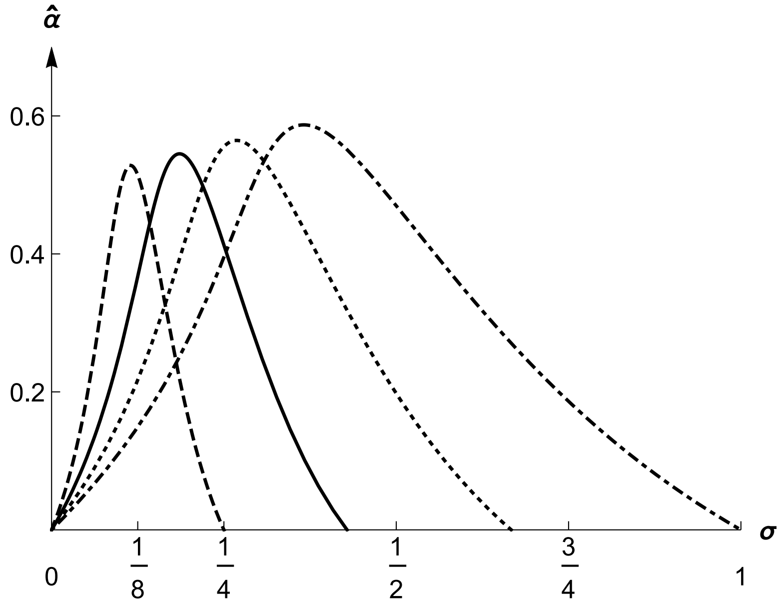

FIGURE 1: $\hat{\alpha}$ as a function of σ for $\tau = 0.1$ (dashed), $\tau = 0.15$ (solid), $\tau = 0.20$ (dotted), and $\tau = 0.25$ (dash-dotted).

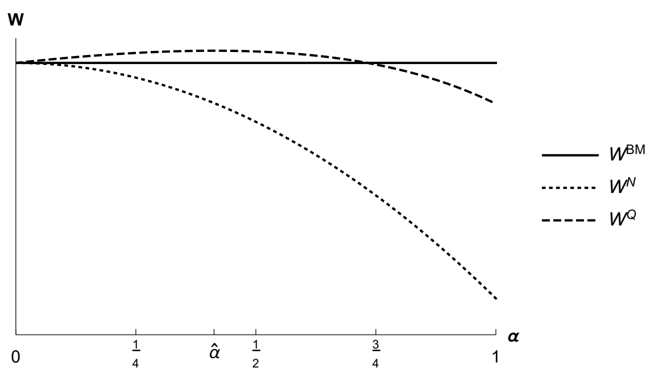

FIGURE 2: Comparison of welfare for $v = 2,\ c_Q = 0.5,\ \tau = 0.15,\ \sigma = 0.25$

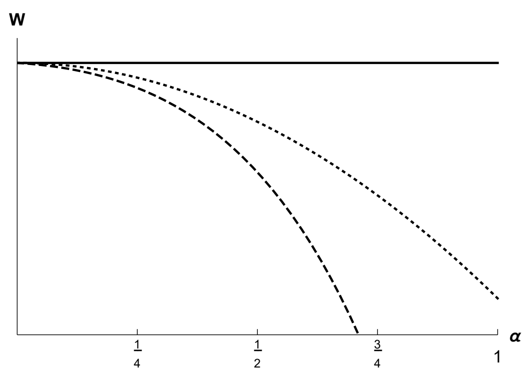

FIGURE 3: Comparison of welfare for $v = 2,\ c_Q = 0.5,\ \tau = 0.15,\ \sigma = 0.5$

Figures 2 and 3 graphically illustrate the development of welfare in the market share of the e-marketplace for a numerical setting with a variation in the salience parameter σ. In Figure 2, $\hat{\alpha} \approx 0.413$ is the welfare maximizing market share of the e-marketplace for this setting. For the used specification of $\tau = 0.15$, we have $\frac{2\tau}{1-2\tau} = \frac{3}{7}$. For values of the salience parameter σ larger than this, the welfare with salient quality (W^Q) is strictly decreasing in the entire range of α (see Figure 3), while it is increasing till $\hat{\alpha}$ for values smaller than this (see Figure 2). Therefore, the welfare in the case of salient quality can exceed the benchmark level. Hence, the existence of the e-marketplace can be beneficial, even though the gains of the firms and the platform arise on cost of consumers - as discussed above. If the focus of consumers on quality becomes too large, the negative consequences for consumers induced by smaller quality-price ratios lead to decreasing welfare in total. In the course of this effect, welfare can be worse than under competition with no attribute being salient (W^N).

2.5 Discussion and Conclusion

The model presented here helps to understand how the provision of vertically differentiated products is influenced by the fact that an increasing amount of consumers use e-marketplaces to search and buy products. Based on the assumption that the e-marketplace is able to direct the focus of consumers to specific attributes of a product, the competing firms can make strategic use of the ability to decide which dimension should be salient on the platform to shift the focus of potential buyers towards the quality dimension.

I find that, in the absence of the salience mechanism, the vertical product differentiation is smaller with a share of consumers that exclusively use the e-marketplace to buy the products compared to the benchmark without an e-marketplace. Due to the proportional commission fee of the platform, the profitability of quality is reduced. Consumers benefit from reduced prices in this case, yet this comes at the expense of reduced quality.

Introducing the salience mechanism shows that the firms strategically use the ability to drive the focus of consumers towards the quality attribute of the products, resulting in higher quality, reduced price competition, and thus increased profits for the firms as well as the e-marketplace. This procedure can be beneficial in terms of welfare for moderate levels of salience of quality. If the focus of consumers on this attribute becomes too large, the decrease in consumer surplus exceeds the additional gains of the firms and the e-marketplace. Therefore, it is harmful for total welfare. A social planer that aims to maximize welfare could influence this procedure by regulating the contracts between the firms and the e-marketplace. If the costs for making a specific attribute salient exceed a certain level, it is not profitable for the firms to use the salience mechanism. Depending on how strong the salience mechanism directs the focus, it can be welfare maximizing to deter its use by regulation of the costs.

If, in contrast to the assumption in this paper, the consumers can decide which attribute is salient on the e-marketplace in the first stage of the game, they would prefer salient prices. This is maximizing the consumer surplus due to increased price competition between the two firms, but comes at the expense of reduced quality offered by the high quality firm. If the e-marketplace itself can decide which attribute to make salient, it maximizes its' profit gained through the proportional commission fee by making the quality salient. This increases the prices of both high and low quality products as well

as the share of the (more expensive) high quality good sold on the platform.
The assumption that the firms offer their products without price discrimination between e-marketplace and direct consumers does marginally influence the results presented here. If the firms could charge different prices from the two groups of consumers they serve, they would try to increase their market share on the direct selling channel by reducing the prices there. This results in a lower quality of the high quality offering firm. If the firms are allowed to price and quality discriminate between the consumers of the different selling channels, the price and quality decision for the e-marketplace is equal to the results given in Section 2.3 for a level of $\alpha = 1$, while the outside market is served with the benchmark prices and qualities. Endogenous consumer decisions between those two selling channels and the firms strategic incentives in this setting can be an interesting subject of investigation.
Generally, e-marketplaces have become major players in modern consumer markets. The design of those platforms and the embedded features they offer for either or both firms and/or consumers can influence the decision making process of market actors and, therefore, the market itself. Thus analyzing the impact of different mechanisms within those markets can be an important task for both researchers and policy makers.

3 Limited Perception and Price Discrimination in a Model of Horizontal Product Differentiation

Marc P. Saur, Stefanie Y. Schmitt, Markus G. Schlatterer

Abstract

We analyze price discrimination in a model of horizontal product differentiation where consumers have limited perception. Consumers with limited perception do not necessarily notice all goods in the market. Limited perception thus offers a market segmentation into consumers who notice only one good and consumers who notice all goods. Our objective is to analyze whether less perception is harmful to consumers when firms use this segmentation to price discriminate. We show that product differentiation under limited perception is less extreme than under full perception. Consequently, despite firms' ability to price discriminate, average prices may be lower under limited than under full perception. In addition, we show that consumer surplus and welfare are not maximized under full perception but increase for some degree of limited perception.

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3.1 Introduction

Price discrimination is an extensively discussed topic in theoretical economics.[6] In general, the ability of a firm to price discriminate increases with the amount of information about potential consumers that is available. E-commerce and technological advances increase data availability and offer firms more opportunities to price discriminate.[7] In addition, increasing evidence demonstrates that consumers have limited perception

[6]See Armstrong (2006b) for an overview.

[7]For example, the price in online stores' depends on the geographical location of consumers (Mikians, Gyarmati, Erramilli, and Laoutaris, 2013) or on the device used for the transaction (Hannak, Soeller, Lazer, Mislove, and Wilson, 2014).

which results in imperfect information about all available goods in the market (see, e.g., Goeree, 2008; Honka, Hortaçsu, and Vitorino, 2017). These consumers are less responsive to price changes. The increase in data availability allows firms to find these consumers and charge only these consumers higher prices.

Our objective is to study the implications of such price discrimination in a model of horizontal product differentiation. In particular, we analyze whether consumers benefit from more perception. We follow Hotelling (1929) in modeling horizontal product differentiation as a real line $[0, 1]$ where the position of a consumer in the product space describes that consumer's preferred version of the good. Experimental and empirical evidence shows that not all consumers are aware of all goods (see, e.g., Goeree, 2008; Honka, Hortaçsu, and Vitorino, 2017) and that similarity matters for perception (see, e.g., Simons and Chabris, 1999; Most, Simons, Scholl, Jimenez, Clifford, and Chabris, 2001; Drew and Stothart, 2016). Therefore, we assume that consumers only perceive a fraction of the product space. In particular, we model perception as a spotlight that only highlights the section of the product space around the consumers' preferred version of the good, i.e., all goods in their *perception radius*. Therefore, consumers only notice goods that are relatively similar to their preferred good and are not necessarily aware of all available goods.

Their limited perception divides consumers into three groups: consumers who notice neither, one, or both firms. In particular, firms have to compete for consumers who notice both firms, but are monopolists for consumers who notice only one firm. Firms can charge consumers who notice only one firm a higher price without risking that these captive consumers switch to the competitor. In contrast, firms cannot charge consumers who notice both firms a high price, because these consumers would then switch to the competitor. Firms can influence which consumers notice them by choosing their location in the product space. The product differentiation thus determines the firms ability to price discriminate. When firms use this market segmentation into consumers who notice only one firm and consumers who notice both firms to price discriminate, consumers with less information pay higher prices. Consequently, more perception, which increases the fraction of fully informed consumers, might be beneficial to consumers. Our objective is to investigate whether consumers benefit from higher levels of perception.

With this model we capture a series of situations. First and foremost, e-commerce offers firms the opportunity to gather information about consumers to segment them and the ability to test prices quickly and cheaply on different consumer segments (Baker, Marn, and Zawada, 2001). Thus firms can identify which consumer segments are responsive to discounts, for example, because they also take goods from competitors into account and which consumer segments are unresponsive because these consumers only notice

one firm.[8]
Furthermore, consumers often actively constrain their perception to a limited number of goods in the market. For example, when searching for goods on the internet, consumers often use filters. Filters reduce the number of goods displayed to consumers. The goods offered to consumers depend on the filter and the goods' characteristics. In our two goods case, if consumers use a filter that describes both goods sufficiently well, both goods are offered. If consumers use a filter that only one good passes, only that good is offered. Some consumers whose preferences are too far from the available goods will be offered no good. The use of filters gives firms information about the preferences of consumers. Firms can then use this information to charge the consumers different prices. For example, consider two firms selling laptops. One sells a high-power gaming laptop, the other an ultra-portable office notebook. Consumers who search for gaming laptops or office notebooks are only displayed one good each, while consumers who search for a normal laptop are displayed both. Thus the use of filters segments the market with respect to the number of goods displayed to consumers. This in turn offers firms market power over consumers who notice only one good.[9]
In addition, because we model horizontal product differentiation following Hotelling (1929), the model supports a geographical interpretation. Consumers looking for a restaurant might perceive only restaurants that are close enough. If a restaurant is located too far from the consumer, it does not come to mind, even if the consumer has noticed it in the past: The restaurant is *out of sight*, and therefore *out of mind*.[10]
In addition, online maps display details such as restaurants only if the user zooms in. Thus only close-by restaurants are displayed. If firms know that consumers only consider restaurants that are close enough, they can infer which consumers consider both firms and send these consumers coupons.
Intuition suggests that limited perception of consumers is harmful to consumers, because limited perception increases firms' market power, especially if firms can exploit this market power which they have over captive consumers by charging these consumers higher prices. However, we show that full perception is not optimal for consumers. Under full perception, firms maximally differentiate their products and exploit this market power by setting higher prices. Nevertheless, very low levels of perception are also detrimental to consumers: Firms act as monopolists for all consumers, who then pay a high monopoly price. Yet, for intermediate levels of perception, consumers pay lower prices than under full perception despite firms' ability to price discriminate. With

[8] Wallheimer (2018) refers to software that can tell a firm whether a consumer already visited a competitors' website.

[9] Hillenbrand and Hippel (2019) find in an experiment that a monopolist charges higher prices to consumers who use more filters, i.e., to consumers with stronger restrictions for a match.

[10] Honka, Hortaçsu, and Vitorino (2017) analyze consumers' awareness of banks and find that local branch presence affects awareness.

these intermediate levels of perception, compared to full perception, firms locate closer to the efficient locations, i.e., the locations that minimize the average distance between consumers and firms. This increases price competition for consumers who notice both firms. In addition, the fraction of consumers who notice only one firm is sufficiently small. Thus the welfare gain of the consumers who notice both firms and who pay a lower price than under full perception outweighs the welfare loss of the consumers who notice only one firm and have to pay the higher monopoly price. Furthermore, as the ability to price discriminate hinges on firms' product differentiation, firms do not always find it profitable to differentiate their products in a way that allows them to price discriminate. Rather, for (close to) full perception of consumers, firms locate such that all consumers notice both firms which means firms have no basis for price discrimination.

The remainder of the article is structured as follows. Section 3.2 discusses our contributions to the related literature. Section 3.3 introduces the model. In section 3.4, we derive the subgame-perfect equilibrium and discuss the resulting welfare. Section 3.5 discusses the results and concludes. All proofs are in the appendix.

3.2 Related literature

In our model, the limited perception of consumers leads to imperfect information and information heterogeneity. In industrial organization models, imperfect information and information heterogeneity are classically the result of an exogenous division of the consumers into informed and uninformed (e.g., Varian, 1980; Polo, 1991; Schultz, 2004), search costs differing between consumers (e.g., Salop and Stiglitz, 1977; Stahl II, 1989), or informative advertising which does not reach all consumers (e.g., Butters, 1977; Grossman and Shapiro, 1984; Meurer and Stahl II, 1994; Bester and Petrakis, 1995). Yet, the literature also increasingly discusses limited perception as a source of imperfect information and information heterogeneity. Our approach of modeling limited perception falls into the category of consideration set formation (e.g., Eliaz and Spiegler, 2011a,b; Manzini and Mariotti, 2018; Astorne-Figari, López, and Yankelevich, 2019). That is, instead of considering all goods in the market, consumers consider only goods from a subset—the so-called consideration set.

In horizontal product differentiation models, imperfect information and information heterogeneity have been shown to affect, for example, prices and consumer welfare. For instance, Hefti (2018) demonstrates that limited attention of consumers, which leads to imperfect information, induces more firms to enter the market. But as limited attention restricts the number of firms that consumers notice, the increased entry of firms reduces the likelihood that consumers find a good match and thus reduces consumer welfare. Cosandier, Garcia, and Knauff (2018) show that if goods are substitutes and the (exogenous) fraction of consumers who notice all firms in the market increases, prices decrease. In contrast, if firms can influence the fraction of fully informed consumers via informative advertising, a higher fraction of fully informed consumers can lead to higher prices (Soberman, 2004; Boone and Pottersz, 2006).

Closest to our *perception radius* are Roy (2000) and Armstrong and Vickers (2020). Both allow a spatial interpretation where only consumers located within a radius κ around the firm notice the firm. In Roy (2000), firms advertise to an interval of consumers starting from the endpoints of the Hotelling line. This corresponds to the special case in our model where firms locate at the endpoints of the Hotelling line (and would be able to influence the perception radii of consumers). In Armstrong and Vickers (2020), each firm is noticed by a random fraction of consumers. Yet, the model supports a two-dimensional spatial interpretation where the consumers who notice a firm are located within a circle of the location of the firm. Our perception radius is a one-dimensional interpretation of this. However, in contrast to our model, in Roy (2000) and Armstrong and Vickers (2020), firms' locations are fixed and goods are homogeneous such that the location of consumers does not affect the valuation of the goods. Therefore, product differentiation is not part of their analysis.

Information heterogeneity among consumers implies a segmentation of the market. We extend these earlier models by allowing firms to use this segmentation to price discriminate. Our main contribution is thus to the literature on perception-based price discrimination (Heidhues and Köszegi, 2017; Armstrong and Vickers, 2019; Mauring, 2020). Heidhues and Köszegi (2017) consider price-discrimination between naive and sophisticated consumers and show that the welfare effects of naïveté-based discrimination depend on whether trades with consumers lead to distortions. Yet, naïveté-based discrimination is never pareto-improving. Mauring (2020) discusses probabilistic price discrimination with respect to consumers' search costs. Mauring (2020) shows that an increase in the number of firms in the market may induce firms to focus solely on consumers with high search costs which increases profits but decreases overall welfare.

Most closely related to our article is Armstrong and Vickers (2019). In Armstrong and Vickers (2019), firms produce a homogeneous good. Some consumers are captive to a particular firm, whereas some consumers can compare the offers of firms. This distinction is exogenous and offers the segmentation for price discrimination. Armstrong and Vickers (2019) point out that the overall effect of price discrimination between informed and uninformed consumers on consumer surplus can be positive in asymmetric markets. The modeling of captive consumers in Armstrong and Vickers (2019) is identical to Armstrong and Vickers (2020) and thus also supports a spatial interpretation. Yet, in contrast to our paper, Armstrong and Vickers (2019) consider homogeneous products, such that location of firms does not play a role for consumers' utility. Thus

Armstrong and Vickers (2019) also do not consider the location decisions of firms. We contribute to this literature by extending the analysis from a setting where the distinction between consumers is exogenously given as in Heidhues and Köszegi (2017), Armstrong and Vickers (2019), and Mauring (2020), to arising endogenously. Furthermore, we focus on the resulting product differentiation. Our contribution allows for a better understanding of the consequences of perception-based price discrimination. In particular, we analyze whether consumers benefit from higher levels of perception.

Although firms in our analysis discriminate with respect to the perception of consumers, because of our setup this corresponds to charging different segments on the Hotelling line different prices (e.g., Fudenberg and Tirole, 2000; Liu and Serfes, 2004; Choe, King, and Matsushima, 2018; Feng and Ma, 2018).[11] In Fudenberg and Tirole (2000) and Choe, King, and Matsushima (2018), a firm offers different prices to its own past consumers and its rival's past consumers. This results in (inefficient) switching between firms (Fudenberg and Tirole, 2000) and affects profits negatively (Choe, King, and Matsushima, 2018). Liu and Serfes (2004) focus on firms' decision to buy information about the segments in which consumers are located. Liu and Serfes (2004) show that firms do not buy this information if the segmentation is coarse. Yet, consumers prefer firms to price discriminate. Feng and Ma (2018) analyze the location decision of firms that face an exogenous segmentation and find that maximum product differentiation no longer holds universally. Although, the two segment case in Liu and Serfes (2004) and Feng and Ma (2018) corresponds to our setup in the sense that firms choose two different prices, they model the segmentation as exogenous. In contrast, in our model, firms can choose their location and thereby influence the segmentation. In addition, in contrast to our model in Liu and Serfes (2004) and Feng and Ma (2018) consumers in all segments are aware of all firms.

3.3 The model

We consider a market for a horizontally differentiated good where two firms, firm 1 and firm 2, compete for a unit mass of consumers. We assume that firms have identical marginal costs that we set to 0. Consumers are uniformly distributed on the interval $[0, 1]$. The location $x \in [0, 1]$ of a consumer describes the consumer's most preferred version of the good. Initially, firms decide which version of the good to produce by choosing their positions $y_1, y_2 \in [0, 1]$. Without loss of generality, we assume $y_1 \leq y_2$. Each consumer wants to buy exactly one unit of the good. If a consumer does not buy the good, her utility is normalized to 0. If the consumer located at $x \in [0, 1]$ buys the

[11]The literature on price discrimination in spatial models is very broad and includes price discrimination with respect to valuation, preference for differentiation, or location of consumers (see, e.g., Armstrong, 2006b, for a survey).

good from firm $i \in \{1, 2\}$, the consumer's utility is

$$u_x(i) = v - p_i - (x - y_i)^2,$$

where p_i is the price at which firm i sells the good, $y_i \in [0, 1]$ is the location of firm i, and v is the gross utility of the good. We assume $v > 3$; this ensures that, in equilibrium, all consumers who notice at least one firm buy from one of these firms.
However, in our model, consumers' perception is limited and this constraint may prevent purchase: Each consumer only considers firms within her *perception radius* κ. Then, the consumer at position x only notices firm i on position y_i if $|x - y_i| \leq \kappa$, where $0 < \kappa \leq 1$. Firms thus enter the consideration set[12] of a consumer, if they produce a version of the good that fits the consumer's taste well enough. If $|x - y_i| > \kappa$, the consumer does not even know (or remember) that firm i exists and, consequently, does not consider buying from firm i. Thus limited perception may prevent purchase from a firm that has the overall better offer. Generally, if $\kappa = 1$, every consumer on $[0, 1]$ observes any point in $[0, 1]$. Therefore, this limiting case represents the standard Hotelling model where the choice set is identical to the consideration set.
From the perspective of firm $i \in \{1, 2\}$, the perception radii of consumers suggest that the firm can only reach consumers who are close enough. That means, the firm can only reach consumers who are in $[y_i - \kappa, y_i + \kappa]$. We call this interval the *reach* of firm i. Consumers outside the reach of firm i do not perceive firm i and thus never buy from firm i. Thus consumers' limited perception restricts the demand firms can capture.
If the firms' reaches do not overlap, i.e.,$[y_1 - \kappa, y_1 + \kappa] \cap [y_2 - \kappa, y_2 + \kappa] = \emptyset$ or, equivalently, $y_1 + \kappa \leq y_2 - \kappa$, no consumer who notices firm 1 notices firm 2 and vice versa. Thus each firm is a monopolist in its reach. Figure 4 illustrates such a situation for $y_1 > \kappa$ and $y_2 > 1 - \kappa$.

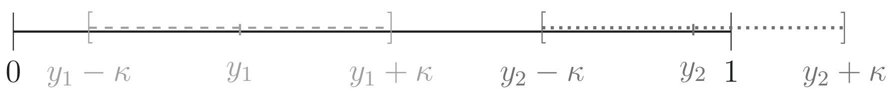

FIGURE 4: Example of non-overlapping reaches of firm 1 (dashed) and firm 2 (dotted).

If the reaches overlap, i.e., $[y_1 - \kappa, y_1 + \kappa] \cap [y_2 - \kappa, y_2 + \kappa] \neq \emptyset$ or, equivalently, $y_1 + \kappa > y_2 - \kappa$, some consumers notice both firms (see Figure 5 for an example). In particular, all consumers $x \in [0, 1]$ such that $y_1 - \kappa \leq x < y_2 - \kappa$ notice only firm 1. These consumers buy from firm 1 if the utility of buying from firm 1 exceeds the utility of the outside option. All consumers $x \in [0, 1]$ such that $y_2 - \kappa \leq x \leq y_1 + \kappa$ notice

[12]The consideration set is a subset of the choice set. The choice set includes all available options (here, buying from firm 1 or firm 2, or not buying). The consideration set includes only those elements the consumer actively considers (here, not buying and buying from any of the firms inside the consumer's perception radius).

both firms. Consumers buy from firm 1 if they prefer firm 1, i.e., $v - p_1 - (x - y_1)^2 \geq v - p_2 - (x - y_2)^2$.[13] Similarly, consumers buy from firm 2 if they prefer firm 2. We denote the consumer who is indifferent between buying from firm 1 and buying from firm 2 by

$$\hat{x} = \frac{p_2 - p_1}{2(y_2 - y_1)} + \frac{y_1 + y_2}{2}. \tag{1}$$

Thus everyone in the interval $[y_2 - \kappa, \hat{x}]$ buys from firm 1 and everyone in the interval $[\hat{x}, y_1 + \kappa]$ buys from firm 2. All consumers $x \in [0, 1]$ such that $y_1 + \kappa < x \leq y_2 + \kappa$ notice only firm 2. These consumers buy from firm 2 if the utility of buying from firm 2 exceeds the utility of the outside option.

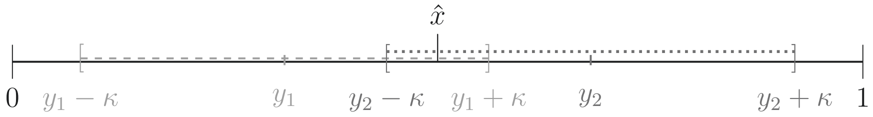

FIGURE 5: Example of overlapping reaches of firm 1 (dashed) and firm 2 (dotted).

The two firms play a two-stage game: In stage one, firms simultaneously and independently choose locations in the product space; in stage two, each firm observes the location of its competitor and, then, the firms simultaneously and independently set prices. Each firm (potentially) faces two groups of consumers. Consumers who notice one firm and consumers who notice both firms. Firms are monopolists for consumers who notice only one firm, but have to compete for the consumers who notice both firms. By choosing their location in the product space, firms can influence the size of their two groups of consumers. We assume that firms can distinguish between these two groups of consumers and thus charge the two groups different prices: Firms charge a monopoly price p_i^m from the consumers who notice only one firm, and a competition price p_i^c from the consumers who notice both firms. In the follwoing, we solve for subgame-perfect equilibria by backward induction.

3.4 Results

In the price-setting stage, firms set prices to maximize profits given the locations chosen in the first stage. Profits can be split into two parts; the profits from the monopoly

[13] In addition, the utility of buying needs to exceed the utility of the outside option. In equilibrium, this is always the case.

and the profits from competition:

$$\Pi_1(p_1^m, p_1^c, p_2^c, y_1, y_2) = \Pi_1^m(p_1^m, y_1, y_2) + \Pi_1^c(p_1^c, p_2^c, y_1, y_2)$$
$$\Pi_2(p_2^m, p_1^c, p_2^c, y_1, y_2) = \Pi_2^m(p_2^m, y_1, y_2) + \Pi_2^c(p_1^c, p_2^c, y_1, y_2).$$

We can solve for the two prices separately. Firm 1's monopoly demand consists of all consumers who notice only firm 1, i.e., $x \in [y_1-\kappa, y_1+\kappa] \cap [0,1]$ and $x \notin [y_2-\kappa, y_2+\kappa]$, and whose utility exceeds zero: $u_1(x) = v - p_1^m - (x-y_1)^2 \geq 0 \Leftrightarrow y_1 - \sqrt{v-p_1^m} \leq x \leq y_1 + \sqrt{v-p_1^m}$. Thus as long as $p_1^m \leq v - \kappa^2$, all consumers who notice only firm 1 have a positive utility and buy from firm 1. If $v > p_1^m > v - \kappa^2$, all consumers who notice only firm 1 and are in $[y_1 - \sqrt{v-p_1^m}, y_1 + \sqrt{v-p_1^m}]$ have a positive utility and buy from firm 1. If $p_1^m > v$, the monopoly price exceeds the gross utility of all consumers and no consumer buys from firm 1. Thus the profit of firm 1 from the monopoly is

$$\Pi_1^m(p_1^m, y_1, y_2) =$$
$$= \begin{cases} p_1^m(\min\{y_2-\kappa, y_1+\kappa\} - \max\{0, y_1-\kappa\}) & \text{if } p_1^m \leq v-\kappa^2 \\ p_1^m(\min\{y_2-\kappa, y_1+\sqrt{v-p_1^m}\} - \max\{0, y_1-\sqrt{v-p_1^m}\}) & \text{if } v-\kappa^2 < p_1^m \leq v \\ p_1^m \times 0 & \text{if } v < p_1^m. \end{cases}$$

Similarly, the profit of firm 2 from the monopoly is

$$\Pi_2^m(p_2^m, y_1, y_2) =$$
$$= \begin{cases} p_2^m(\min\{y_2+\kappa, 1\} - \max\{y_2-\kappa, y_1+\kappa\}) & \text{if } p_2^m \leq v-\kappa^2 \\ p_2^m(\min\{y_2+\sqrt{v-p_2^m}, 1\} - \max\{y_2-\sqrt{v-p_2^m}, y_1+\kappa\}) & \text{if } v-\kappa^2 < p_2^m \leq v \\ p_2^m \times 0 & \text{if } v < p_2^m. \end{cases}$$

In general, the maximum monopoly demand that firm 1 can receive is given by $\min\{y_2-\kappa, y_1+\kappa\} - \max\{0, y_1-\kappa\}$. For $v > 3$, firm 1 has an incentive to set its monopoly price such that all consumers who notice only firm 1 are willing to buy from firm 1. The detailed derivation is in the appendix.

If the firms' reaches do not overlap (i.e., $y_1+\kappa \leq y_2-\kappa$), the last consumer who notices only firm 1 is at $x = y_1+\kappa$ and firm 1 sets a price $p_1^m = v-\kappa^2$. If the firms' reaches overlap (i.e., $y_1+\kappa > y_2-\kappa$) and $y_1 \geq \kappa$, the last consumer who notices only firm 1 is at $x = y_1-\kappa$ and firm 1 sets a price $p_1^m = v-\kappa^2$. Thus when firm 1 can fully exploit one side of its reach, firm 1 sets the monopoly price such that all of these consumers are willing to buy from firm 1. Otherwise, firm 1 sets its monopoly price to capture the last consumer who notices only firm 1. Then, if the reach of firm 1 yields more monopoly demand on the left side than on the right side of firm 1 (i.e., $y_1 - 0 \geq y_2-\kappa-y_1$), the last consumer who notices just firm 1 is at $x = 0$ and firm

1 sets a price $p_1^m = v - y_1^2$. If the reach yields more demand on the right side (i.e., $y_1 - 0 < y_2 - \kappa - y_1$), the last consumer who notices just firm 1 is at $x = y_2 - \kappa$ and firm 1 sets a price $p_1^m = v - (y_1 - y_2 + \kappa)^2$.
The monopoly price of firm 1 is, therefore,

$$p_1^{m*} = \begin{cases} v - \kappa^2 & \text{if } y_1 + \kappa \leq y_2 - \kappa \text{ or } y_1 + \kappa > y_2 - \kappa \text{ with } y_1 \geq \kappa \\ v - y_1^2 & \text{if } y_1 + \kappa > y_2 - \kappa \text{ with } y_2 - \kappa - y_1 \leq y_1 < \kappa \\ v - (y_1 - y_2 + \kappa)^2 & \text{if } y_1 + \kappa > y_2 - \kappa \text{ with } y_1 < y_2 - \kappa - y_1 \text{ with } y_1 < \kappa. \end{cases}$$

Similarly, the monopoly price of firm 2 is

$$p_2^{m*} =$$
$$= \begin{cases} v - \kappa^2 & \text{if } y_1 + \kappa \leq y_2 - \kappa \text{ or } y_1 + \kappa > y_2 - \kappa \text{ with } y_2 \leq 1 - \kappa \\ v - (1 - y_2)^2 & \text{if } y_1 + \kappa > y_2 - \kappa \text{ with } 1 - y_2 \geq y_2 - y_1 - \kappa \text{ with } y_2 > 1 - \kappa \\ v - (y_2 - y_1 - \kappa)^2 & \text{if } y_1 + \kappa > y_2 - \kappa \text{ with } 1 - y_2 < y_2 - y_1 - \kappa \text{ with } y_2 > 1 - \kappa. \end{cases}$$

If the firms' reaches overlap, i.e., $y_1 + \kappa > y_2 - \kappa$, firms also face consumers who notice both firms. That means, firms compete for consumers in the interval $[y_2 - \kappa, y_1 + \kappa] \cap [0, 1] = [\max\{0, y_2 - \kappa\}, \min\{y_1 + \kappa, 1\}]$. All consumers in this interval located to the left of the indifferent consumer $\hat{x}$ buy from firm 1, all others from firm 2. In equilibrium, firms set prices such that both firms receive some demand.[14] If $y_1 \neq y_2$, the competition profits of firm 1 and firm 2 are

$$\begin{aligned} \Pi_1^c(p_1^c, p_2^c, y_1, y_2) &= p_1^c \left(\hat{x} - \max\{0, y_2 - \kappa\}\right) \\ &= p_1^c \left(\frac{p_2^c - p_1^c}{2(y_2 - y_1)} + \frac{y_1 + y_2}{2} - \max\{0, y_2 - \kappa\}\right) \end{aligned}$$

$$\begin{aligned} \Pi_2^c(p_1^c, p_2^c, y_1, y_2) &= p_2^c \left(\min\{y_1 + \kappa, 1\} - \hat{x}\right) \\ &= p_2^c \left(\min\{y_1 + \kappa, 1\} - \frac{p_2^c - p_1^c}{2(y_2 - y_1)} - \frac{y_1 + y_2}{2}\right). \end{aligned}$$

Firms set their prices p_1^c and p_2^c to maximize profits. The best replies of firm 1 and

[14] If both firms would set prices such that one firm receives the full competition demand and the other firm receives zero competition demand, the firm that receives zero demand can strictly increase its profit by choosing the (strictly positive) price of its competitor. Thus such prices cannot exist in equilibrium.

firm 2 are

$$
\begin{aligned}
p_1^{c*}(p_2^c) &= \frac{p_2^c}{2} + (y_1 - y_2)\left(\max\{0, y_2 - \kappa\} - \frac{y_1 + y_2}{2}\right) \\
p_2^{c*}(p_1^c) &= \frac{p_1^c}{2} + (y_1 - y_2)\left(-\min\{y_1 + \kappa, 1\} + \frac{y_1 + y_2}{2}\right).
\end{aligned}
$$

The equilibrium prices are, then,

$$
\begin{aligned}
p_1^{c*} &= \frac{1}{3}(y_1 - y_2)(4\max\{0, y_2 - \kappa\} - 2\min\{y_1 + \kappa, 1\} - y_1 - y_2) \\
p_2^{c*} &= \frac{1}{3}(y_1 - y_2)(2\max\{0, y_2 - \kappa\} - 4\min\{y_1 + \kappa, 1\} + y_1 + y_2).
\end{aligned}
$$

The prices are increasing in the distance between firm 1 and firm 2. If firms have chosen the same location in the first stage, i.e., $y_1 = y_2$, price competition will ensure that $p_1^{c*} = p_2^{c*} = 0$. Taking these equilibrium prices, p_1^{m*}, p_2^{m*}, p_1^{c*}, and p_2^{c*}, the updated profits are

$$
\Pi_1(y_1, y_2) = \begin{cases} p_1^{m*} x_1^m & \text{if } y_1 + \kappa \le y_2 - \kappa \\ p_1^{m*} x_1^m + p_1^{c*} x_1^c & \text{if } 0 < y_2 - \kappa < y_1 + \kappa \\ p_1^{c*} x_1^c & \text{if } y_2 - \kappa \le 0 < y_1 + \kappa \end{cases} \tag{2}
$$

$$
\Pi_2(y_1, y_2) = \begin{cases} p_2^{m*} x_2^m & \text{if } y_1 + \kappa \le y_2 - \kappa \\ p_2^{m*} x_2^m + p_2^{c*} x_2^c & \text{if } y_2 - \kappa < y_1 + \kappa < 1 \\ p_2^{c*} x_2^c & \text{if } y_2 - \kappa < 1 \le y_1 + \kappa \end{cases} \tag{3}
$$

$$
\begin{aligned}
\text{where } \ x_1^m &= \min\{y_2 - \kappa, y_1 + \kappa\} - \max\{0, y_1 - \kappa\} \\
x_2^m &= \min\{y_2 + \kappa, 1\} - \max\{y_2 - \kappa, y_1 + \kappa\} \\
x_1^c(p_1^{c*}, p_2^{c*}) &= -\frac{1}{6}\left(4\max\{0, y_2 - \kappa\} - 2\min\{y_1 + \kappa, 1\} - y_1 - y_2\right) \\
x_2^c(p_1^{c*}, p_2^{c*}) &= -\frac{1}{6}\left(2\max\{0, y_2 - \kappa\} - 4\min\{y_1 + \kappa, 1\} + y_1 + y_2\right)
\end{aligned}
$$

In the first stage, firms maximize profits by choosing their location in the product space. The structure of the profit functions (2) and (3) gives rise to a multitude of case distinctions. The first case of each profit function captures the situation that no consumer notices both firms. Thus both firms operate as pure monopolists. The second case captures the situation that firm i faces some consumers who only notice firm i and some consumers who also notice firm j. Therefore, the profit function consists of two terms: The profit from operating as a monopolist and the profit from competition. The third case captures that all consumers of firm i also notice firm j. Thus firm i only serves a competitive market. The size of the demand depends on the locations of the firms. Firms maximize profits over all cases to derive their best replies. Figure 6 illustrates the subgame-perfect equilibrium locations of firm 1 and firm 2.

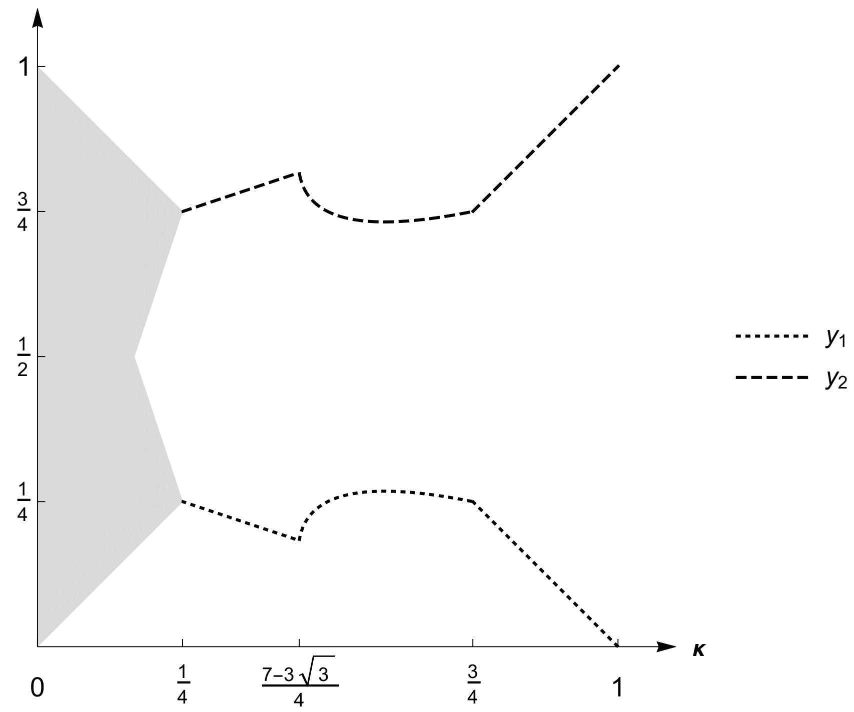

FIGURE 6: Subgame-perfect equilibrium locations of firm 1 (dotted) and firm 2 (dashed) as a function of κ. For $\kappa \leq 1/4$ a continuum of subgame-perfect equilibria exist, which is illustrated by the gray area .

If $0 < \kappa \leq 1/4$, the firms are able to choose locations such that both firms are monopolists in their complete reaches and firms will do so in all subgame-perfect equilibria. Therefore, firms' reaches do not overlap. Assume the firms' locations induce an overlap of their reaches, i.e., $y_1 + \kappa > y_2 - \kappa$. Then, for $0 < \kappa \leq 1/4$, either $y_1 > \kappa$, $y_2 < 1 - \kappa$, or both. This means, at least one firm is able to move farther away from the opponent and thereby gain additional monopoly demand by simultaneously losing competition demand. As the additional monopoly profit exceeds the lost competition profit, the firm will move farther away until it has reached a full monopoly. Then, if the other firm does not have a full monopoly, because its outer boundary overshoots the product range, e.g., $y_2 + \kappa > 1$, it will move closer to its opponent as it trades no demand for competition demand. This induces the other firm to move farther outwards again until both firms have full monopolies. Consequently, in all subgame-perfect equilibria, both firms have only monopoly demand and all pairs of locations that induce two full monopolies are subgame-perfect equilibria. See the appendix for a formal proof.

If $\kappa > 1/4$, firms are unable to capture two full separate monopolies and competition becomes attractive for firms and is not avoided anymore. Nevertheless, as monopoly prices are higher than competition prices, firms prefer monopoly demand to competition demand. As κ increases, for fixed locations, more consumers notice both firms

and the firms have to compete for these consumers. Generally, if the overlap of the reaches is small, few consumers notice both firms. For these consumers, the distance to the locations of both firms is about equally large. Therefore, for the choice of these consumers, the price is more relevant than the distance. That is, firms face price competition, which leads to low competition prices. As the overlap increases, more consumers notice both firms. Therefore, the fraction of consumers for whom the distance is important for the consumption choice increases. This allows firms to extract higher surplus by setting higher prices. Nevertheless, competition prices are always lower than monopoly prices. Consequently, firms prefer to serve consumers as monopolists.
To dampen the effect that with increasing κ more consumers notice both firms, firms have an incentive to move outwards. Thus both firms only compete for a small number of consumers in the center of the product space and prefer to exploit as much monopoly rent as possible. However, as firms move outwards, a part of the reaches is outside $[0,1]$. Thus the firms make no profit from $[y_1-\kappa,0)$ and $(1,y_2+\kappa]$. When κ increases, these areas from which firms make no profits become larger and, despite firms moving outwards, more consumers notice both firms. As this also increases competition prices, this competition market becomes more tempting for firms. Finally, at $\kappa=(7-3\sqrt{3})/4$ competition is more attractive. Thus with increasing κ, firms move inwards to steal the business of their competitor and to receive a larger share of the competitive market.
As κ increases further, the competition demand increases as well and locating close to the center increases price competition among the firms. This reduces profits. Therefore, for $\kappa \geq (3\sqrt{3}-4)/2$, firms move outwards to avoid competition which increases profits due to higher competition prices. At $\kappa=3/4$, with firms located at $y_1=1/4$ and $y_2=3/4$, all consumers notice both firms, which means that the monopoly profit disappears. Nevertheless, as long as consumers are not fully attentive, not all consumers notice every part of $[0,1]$. Thus firms have no incentive to directly locate at the extremes as this would enable the competitor to capture some fraction of the firm's demand and reduce its profits. In the limit as $\kappa=1$, the classical Hotelling result of maximum product differentiation occurs.
Proposition 2 characterizes the subgame-perfect equilibria for all values of κ. See the Appendix for a formal proof.

Proposition 2 *Characterization of the subgame-perfect equilibria dependent on the perception radius* κ*:*

(i) If $0<\kappa\leq 1/4$*, any pair of locations* $(y_1^*,y_2^*)\in\{(y_1,y_2)|\kappa\leq y_1\leq 1-3\kappa, 3\kappa\leq y_2\leq 1-\kappa, y_2-y_1\geq 2\kappa\}$ *is a subgame-perfect equilibrium. The corresponding equilibrium prices are* $p_1^{m*}=p_2^{m*}=v-\kappa^2$.

(ii) *If* $1/4 < \kappa \leq (7 - 3\sqrt{3})/4$, *the unique subgame-perfect equilibrium locations are* $y_1^* = (1-\kappa)/3$ *and* $y_2^* = (2+\kappa)/3$. *The corresponding equilibrium prices are* $p_1^{m*} = p_2^{m*} = v - ((1-\kappa)/3)^2$ *and* $p_1^{c*} = p_2^{c*} = 1/9(1+2\kappa)(4\kappa-1)$.

(iii) *If* $(7 - 3\sqrt{3})/4 < \kappa \leq 3/4$, *the unique subgame-perfect equilibrium locations are* $y_1^* = 1/4(2 - 3\kappa + \sqrt{\kappa^2 + 4\kappa - 2})$ *and* $y_2^* = 1/4(2+3\kappa - \sqrt{\kappa^2+4\kappa-2})$. *The corresponding equilibrium prices are* $p_1^{m*} = p_2^{m*} = v - 1/16(2-3\kappa+\sqrt{\kappa^2+4\kappa-2})^2$ *and* $p_1^{c*} = p_2^{c*} = 1/2(1 - 2\kappa + \kappa^2 + \kappa\sqrt{\kappa^2+4\kappa-2})$.

(iv) *If* $\kappa > 3/4$, *the unique subgame-perfect equilibrium locations are* $y_1^* = 1 - \kappa$ *and* $y_2^* = \kappa$. *The corresponding equilibrium prices are* $p_1^{c*} = p_2^{c*} = 2\kappa - 1$.

Proposition 2 shows that as $\kappa \to 1$, we approach maximum product differentiation ($y_1 \to 0$ and $y_2 \to 1$). Our model thus captures the standard result of d'Aspremont, Gabszewicz, and Thisse (1979)[15] as the limiting case of fully attentive consumers. For $\kappa = 1/4$, $\kappa = 1/2$, and $\kappa = 3/4$, firms choose the efficient locations, i.e., the locations that minimize the average distance between consumers' and firms' locations $y_1 = 1/4$ and $y_2 = 3/4$. Firms price discrimination depends on their product differentiation. If firms choose locations such that their reaches do not overlap, no consumer notices both firms and all consumers who participate in the market pay the monopoly price. If firms choose locations such that all consumers who notice one firm also notice the other firm, all consumers who participate in the market pay the competition price. Thus firms only choose locations to price discriminate if $1/4 < \kappa \leq 3/4$. For $\kappa \leq 1/4$ and $\kappa > 3/4$, locations that induce a market segmentation are possible, but firms have no incentive to choose those locations. Consequently, firms do not always exploit their ability to price discriminate.

Our main objective is to investigate whether consumers benefit from full perception if firms can exploit limited perception by price discrimination. Our setup implies that consumers can fully avoid this type of price discrimination with full perception, i.e., $\kappa = 1$. Yet, because of firms locations, for $\kappa > 3/4$, firms already no longer price discriminate.

Figure 7 illustrates the consumer surplus, the producer surplus, and the overall welfare (sum of consumer and producer surplus) for different levels of κ.

For $\kappa \leq 1/4$, in the subgame-perfect equilibrium, firms choose locations such that all consumers notice at most one firm. Thus both firms serve the market as monopolists. For $\kappa < 1/4$, some consumers notice neither firm and do not participate in the market. All consumers who notice a firm have to pay the monopoly price. The consumer surplus

[15] d'Aspremont, Gabszewicz, and Thisse (1979) analyze a Hotelling model where firms choose locations and prices and firms have quadratic transportation costs. They find, that firms maximally differentiate their products.

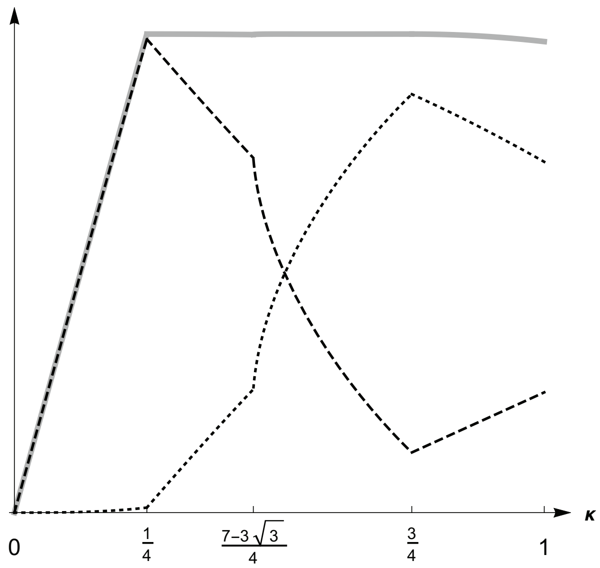

FIGURE 7: Welfare (solid), consumer surplus (dotted), and producer surplus (dashed) as a function of κ for $v = 4$.

is, then,

$$\begin{aligned} CS &= \int_{y_1-\kappa}^{y_1+\kappa} v - (v-\kappa^2) - (x-y_1)^2 dx + \int_{y_2-\kappa}^{y_2+\kappa} v - (v-\kappa^2) - (x-y_2)^2 dx \\ &= \frac{8}{3}\kappa^3 \end{aligned}$$

and the producer surplus is

$$PS = \Pi_1^* + \Pi_2^* = (v-\kappa^2)2\kappa + (v-\kappa^2)2\kappa = (v-\kappa^2)4\kappa.$$

As long as $\kappa \leq 1/4$, an increase in κ implies that firms can reach more consumers without facing competition. In addition, the fraction of consumers who do not participate in the market decreases. Consequently, consumer surplus, producer surplus, and welfare are increasing in κ.

For $\kappa > 1/4$, all consumers buy the good in the subgame-perfect equilibrium. Thus equilibrium prices are only relevant for the division of surplus between firms and consumers, but are irrelevant for total welfare. Welfare is only affected by equilibrium locations and the corresponding disutility consumers receive from buying a non-ideal version of the good.

For $1/4 < \kappa \leq (7-3\sqrt{3})/4$, in the subgame-perfect equilibrium, firms choose locations such that all consumers notice at least one firm. Therefore, all consumers participate in the market. Some consumers notice only one firm and have to pay the monopoly price, whereas, the other consumers notice both firms and pay a lower competition price. Thus the consumer surplus is

$$
\begin{aligned}
CS = & \int_0^{y_2^*-\kappa} v - \left(v - (y_1^*)^2\right) - (x - y_1^*)^2 dx \\
& + \int_{y_2^*-\kappa}^{\hat{x}} v - \frac{1}{9}(1+2\kappa)(4\kappa-1) - (x - y_1^*)^2 dx \\
& + \int_{\hat{x}}^{y_1^*+\kappa} v - \frac{1}{9}(1+2\kappa)(4\kappa-1) - (x - y_2^*)^2 dx \\
& + \int_{y_1^*+\kappa}^{1} v - \left(v - (1 - y_2^*)^2\right) - (x - y_2^*)^2 dx \\
= & v\frac{4\kappa - 1}{3} - \frac{4}{3}\kappa^3 + \frac{1}{3}\kappa^2 - \frac{1}{6}\kappa + \frac{1}{12}
\end{aligned}
$$

and the producer surplus is

$$
\begin{aligned}
PS &= \Pi_1^* + \Pi_2^* \\
&= p_1^{m*}(2-2\kappa)/3 - 1/6(1-4\kappa)p_1^{c*} + p_2^{m*}(2-2\kappa)/3 - 1/6(1-4\kappa)p_2^{c*} \\
&= 2\left(\left(v - \left(\frac{1-\kappa}{3}\right)^2\right)\frac{2-2\kappa}{3} + \frac{(1+2\kappa)(1-4\kappa)^2}{54}\right).
\end{aligned}
$$

As κ increases, more consumers notice both firms, such that more consumers pay the lower competition price. Consequently, producer surplus is decreasing and consumer surplus is increasing in κ. In total, overall welfare is decreasing as locations depart from the efficient locations.
For $(7-3\sqrt{3})/4 < \kappa \leq 3/4$, the consumer surplus is

$$
\begin{aligned}
CS = & \int_0^{y_2^*-\kappa} v - \left(v - (y_1^*)^2\right) - (x - y_1^*)^2 dx + \int_{y_2^*-\kappa}^{\hat{x}} v - p_1^{c*} - (x - y_1^*)^2 dx \\
& + \int_{\hat{x}}^{y_1^*+\kappa} v - p_2^{c*} - (x - y_2^*)^2 dx \\
& + \int_{y_1^*+\kappa}^{1} v - \left(v - (1 - y_2^*)^2\right) - (x - y_2^*)^2 dx \\
= & \frac{24v\kappa - 30\kappa^3 + 18\kappa^2 - 51\kappa + 20 + \sqrt{\kappa^2 + 4\kappa - 2}(24v - 30\kappa^2 + 30\kappa - 9)}{48}
\end{aligned}
$$

and the producer surplus is

$$\begin{aligned}
PS =&\Pi_1^* + \Pi_2^* \\
=&1/4(2-\kappa-\sqrt{\kappa^2+4\kappa-2})p_1^{m*} \\
&+1/16(3\kappa-\sqrt{\kappa^2+4\kappa-2})(\kappa+\sqrt{\kappa^2+4\kappa-2})^2 \\
&+1/4(2-\kappa-\sqrt{\kappa^2+4\kappa-2})p_2^{m*} \\
&+1/16(3\kappa-\sqrt{\kappa^2+4\kappa-2})(\kappa+\sqrt{\kappa^2+4\kappa-2})^2 \\
=&\frac{1}{2}\left(v-\frac{1}{16}\left(2-3\kappa+\sqrt{\kappa^2+4\kappa-2}\right)^2\right)\left(2-\kappa-\sqrt{\kappa^2+4\kappa-2}\right) \\
&+\frac{1}{8}\left(3\kappa-\sqrt{\kappa^2+4\kappa-2}\right)\left(\kappa+\sqrt{\kappa^2+4\kappa-2}\right)^2.
\end{aligned}$$

For $(7-3\sqrt{3})/4 < \kappa \leq 3/4$, in the subgame-perfect equilibrium, the distance between the locations of firm 1 and firm 2 decreases for $\kappa < (3\sqrt{3}-4)/2$ and increases for $\kappa > (3\sqrt{3}-4)/2$. The locations approach the efficient locations ($y_1 = 1/4$ and $y_2 = 3/4$) as $\kappa \to 1/2$ and $\kappa \to 3/4$. Approaching the efficient locations is beneficial to consumers and increases consumer surplus. Yet, increasing product differentiation decreases competition between firms and thus increases competition prices which reduces consumer surplus. However, as κ increases, more consumers notice both firms and more consumers pay the lower competition price. Overall, consumer surplus is increasing in κ. Firms exchange monopoly demand for competition demand. Overall therefore, producer surplus is decreasing in κ. Between $(7-3\sqrt{3})/4 < \kappa \leq 3/4$ welfare is reallocated from firms to consumers. In addition, at $\kappa = 1/2$ and at $\kappa = 3/4$ the firms choose locations that minimize the mean distance between consumers' and firms' locations. Therefore, the welfare reaches its maximum at $\kappa = 1/2$ and at $\kappa = 3/4$.
For $\kappa > 3/4$, firms locate such that all consumers see both firms and as κ increases $y_1 \to 0$ and $y_2 \to 1$. The consumer and the producer surplus are

$$\begin{aligned}
CS &= \int_0^{\hat{x}} v-(2\kappa-1)-(x-(1-\kappa))^2dx + \int_{\hat{x}}^1 v-(2\kappa-1)-(x-\kappa)^2dx \\
&= v-\kappa^2-\frac{1}{2}\kappa+\frac{5}{12} \\
PS &= \Pi_1^*+\Pi_2^* = \frac{2\kappa-1}{2}+\frac{2\kappa-1}{2} = 2\kappa-1.
\end{aligned}$$

For $\kappa > 3/4$, in the subgame-perfect equilibrium, the distance between the firms increases in κ, which allows firms to increase prices. This harms consumers and benefits firms. Therefore, consumer surplus is decreasing and producer surplus is increasing in κ. The overall welfare is decreasing.
Proposition 3 summarizes the welfare analysis.

Proposition 3 *Welfare analysis:*

(i) Producer surplus reaches its maximum at $\kappa = 1/4$.

(ii) Consumer surplus reaches its maximum at $\kappa = 3/4$.

(iii) Welfare reaches its maximum at $\kappa = 1/4$, $\kappa = 1/2$, and $\kappa = 3/4$.

Producer surplus is maximized at $\kappa = 1/4$, where the firms operate as independent monopolists; each firm for exactly half of the consumers. Thus firms cannot increase demand. In addition, firms sell at the monopoly price to all consumers.[16] At $\kappa = 1/4$, consumers actually benefit from product differentiation as firms choose locations $y_1 = 1/4$ and $y_2 = 3/4$ which minimize the mean distance between consumers' and firms' locations. However, all consumers have to pay the monopoly price. Consumer surplus is maximized at $\kappa = 3/4$, where firms also locate at $y_1 = 1/4$ and $y_2 = 3/4$, but all consumers pay the lower competition price.

In summary, some degree of limited perception is actually beneficial to consumers, because the consumers' limited perception induces firms to decrease the average distance between consumers' and firms' location. In addition, limited perception also influences the prices consumers have to pay. The smaller κ, the more consumers have to pay the monopoly price instead of the lower competition price. As κ increases, more consumers pay the lower competition price.

Yet, the competition price also depend on κ. In addition, the competition price is lower at $\kappa = 3/4$ than under full perception because firms do not maximally differentiate their goods. Under full perception, firms maximally differentiate their products to increase their market power which allows them to set higher prices. Therefore, consumers benefit from limited perception as limited perception induces more efficient product differentiation that is favorable to consumers and reduces firms' market power.

Between $\kappa = 1/4$ and $\kappa = 3/4$, welfare is reallocated from firms to consumers as more consumers pay the lower competition price instead of the monopoly price. In addition, at $\kappa = 1/4$, $\kappa = 1/2$, and $\kappa = 3/4$ as firms choose the efficient locations consumer surplus increases. Therefore, welfare reaches its maximum at $\kappa = 1/4$, $\kappa = 1/2$, and $\kappa = 3/4$. That is, welfare is higher under limited than under full perception.

3.5 Conclusion

In this article, we study the effects of limited perception and firms' ability to price discriminate with respect to consumers' perception on horizontal product differentiation and welfare. To capture the effects of limited perception, we introduce a perception radius for each consumer. This radius restricts the consumers' focus to the fraction of

[16] As the game is symmetric and firms always make the same profits, the individual firm also achieves its highest profit at $\kappa = 1/4$

the product space that is close to the consumers' preferred version of the good. Therefore, limited perception reduces competition among firms. Thus it might be expected that limited perception is harmful to the consumers—especially as firms exploit this via price discrimination. However, we find that limited perception is only harmful to consumers for very low levels of perception, but that an intermediate level of perception is actually beneficial to consumers. At low levels of perception, some consumers notice neither firm and are, therefore, unable to participate in the market. But as perception increases, all consumers notice at least one firm. Then, consumers benefit from limited perception, because limited perception induces firms to differentiate their products in a way that is beneficial to consumers. In addition, as firms do not maximally differentiate their products, prices are lower than under perfect perception. Furthermore, firms actually do not always exploit their ability to price discriminate. There are a range of situations where firms prefer to reach all consumers and thus charge all consumers the same price to reaching fewer consumers but charging some of those a higher monopoly price. Overall, we find that the effects on product differentiation, consumer surplus, producer surplus, and welfare are non-monotonic.

Our findings have implications for consumer protection policies. Our results indicate that consumers are not necessarily harmed by their limited perception. The consumers' focus on the product space around their preferred version of the good can result in a differentiation in the market that is preferable to the extreme differentiation found in classical Hotelling models of horizontal product differentiation. As a consequence, informing consumers is not always a beneficial policy.

In addition, firms' ability to price discriminate alone does not have to be problematic. We show that firms do not always make use of price discrimination. Therefore, our analysis illustrates an example where regulating price discrimination is not universally necessary.

3.6 Appendix

3.6.1 Derivation of the monopoly prices

Assume firm 1's monopoly demand on one side is larger than the monopoly demand on the other side. Without loss of generality, we assume that the left side is the larger side. The distance from firm 1's location to the right end of the monopoly area can be denoted as $y_2 - \kappa - y_1$ (as the right side is constrained by the reach of firm 2). Note that this value can also be negative such that the monopoly area is only on the left side of the firm. We can define $d \in [0, \min\{y_1, y_2 - \kappa - y_1, \kappa\}]$ as the distance between the consumer who is indifferent between buying the good at the monopoly price from firm 1 and not buying. Then, we can express the monopoly price and the monopoly profit as a function of the distance d:[17] $p_1^m = v - d^2$ and

$$\Pi_1(d) = (d + y_2 - \kappa - y_1)(v - d^2).$$

The optimal distance is

$$d^* \equiv -\frac{y_2 - y_1 - \kappa}{3} + \frac{1}{3}\sqrt{(y_2 - y_1 - \kappa)^2 + 3v} = \arg\max_d \Pi_1(d).$$

We find that the profit of firm 1 is strictly increasing for $d \in [0, d^*)$. Then, firm 1 is always willing to exploit the whole monopoly range if

$$d^* \geq \kappa \Leftrightarrow v \geq \kappa^2 + 2\kappa(y_2 - y_1).$$

As $0 \leq y_2 - y_1 \leq 1$, $0 < \kappa \leq 1$ and $v > 3$, firm 1 always exploits the whole market. By symmetry, the same holds true for monopolies where the larger part of the monopoly is on the right side of firm 1.[18] Thus in the asymmetric case, the monopoly price is always set to fully exploit the monopoly demand. This must then also be true in the symmetric case (when the monopoly demand on the left side is as large as the monopoly demand on the right side), as now by setting a higher price, the firm would not only loose demand on one but on both sides.

As we have shown, firms have an incentive to always exploit the full monopoly demand. The monopoly price of firm 1 is, therefore,

[17] $u_1(d) = v - p_1^m - d^2 = 0 \Leftrightarrow p_1^m = v - d^2$.

[18] If the right demand side of firm 1 is larger, the profit changes to $\Pi_1 = (d + y_1)(v - d^2)$. However, $d^* \geq \kappa$ and the firms are willing to exploit the whole monopoly market.

$$p_1^{m*} = \begin{cases} v-\kappa^2 & \text{if } y_1+\kappa \le y_2-\kappa \text{ or } y_1+\kappa > y_2-\kappa \text{ with } y_1 \ge \kappa \\ v-y_1^2 & \text{if } y_1+\kappa > y_2-\kappa \text{ with } y_2-\kappa-y_1 \le y_1 < \kappa \\ v-(y_1-y_2+\kappa)^2 & \text{if } y_1+\kappa > y_2-\kappa \text{ with } y_1 < y_2-\kappa-y_1 \text{ with } y_1 < \kappa. \end{cases}$$

By symmetry, firm 2 also always exploits its whole monopoly market. Thus the monopoly price of firm 2 is

$$p_2^{m*} =$$
$$= \begin{cases} v-\kappa^2 & \text{if } y_1+\kappa \le y_2-\kappa \text{ or } y_1+\kappa > y_2-\kappa \text{ with } y_2 \le 1-\kappa \\ v-(1-y_2)^2 & \text{if } y_1+\kappa > y_2-\kappa \text{ with } 1-y_2 \ge y_2-y_1-\kappa \text{ with } y_2 > 1-\kappa \\ v-(y_2-y_1-\kappa)^2 & \text{if } y_1+\kappa > y_2-\kappa \text{ with } 1-y_2 < y_2-y_1-\kappa \text{ with } y_2 > 1-\kappa. \end{cases}$$

3.6.2 Proof of Proposition 2

Subgame-perfect equilibria for $0 < \kappa \le 1/4$

Assume $0 < \kappa \le 1/4$. The proof proceeds in three steps: First, we show that any pair of locations (y_1, y_2) such that the firms' reaches overlap (i.e., $y_1+\kappa > y_2-\kappa$) cannot be a subgame-perfect equilibrium. Second, we show that in the subgame-perfect equilibrium firms do not choose locations such that $y_i < \kappa$ or $y_i > 1-\kappa$. Third, we show that the remaining pairs of locations (y_1, y_2) such that $y_1 \in [\kappa, 1-3\kappa]$ and $y_2 \in [y_1+2\kappa, 1-\kappa]$ are the locations in the subgame-perfect equilibria.

Step 1: Any pair of locations such that $y_1+\kappa > y_2-\kappa$ can never be a subgame-perfect equilibrium. Suppose $y_1+\kappa > y_2-\kappa$, then one firm has an incentive to move away from the opponent without overshooting $[0,1]$, which increases that firm's profit. With $y_1+\kappa > y_2-\kappa$ and $0 < \kappa \le 1/4$, either $y_1 > \kappa$, $y_2 < 1-\kappa$, or both. Suppose $y_1 > \kappa$,

$$\Pi_1(y_1,y_2) = (v-\kappa^2)(y_2-y_1) + \frac{1}{18}(y_2-y_1)(3y_2-4\kappa-2\min\{y_1+\kappa,1\}-y_1)^2$$
$$\frac{\partial \Pi_1(y_1,y_2)}{\partial y_1} =$$
$$= \begin{cases} \underbrace{-v-\kappa^2}_{<-3} + \underbrace{4\kappa(y_2-y_1)}_{<8\kappa^2\le\frac{1}{2}} \underbrace{-\frac{3}{2}(y_2-y_1)^2}_{\le 0} < 0 & \text{if } y_1+\kappa \le 1 \\ \underbrace{\kappa^2-v}_{<0} - \underbrace{\frac{(3y_2-y_1-4\kappa-2)(5y_2-3y_1-4\kappa-2)}{18}}_{\ge 0} < 0 & \text{if } y_1+\kappa > 1 \end{cases}$$

and, by symmetry, if $y_2 < 1-\kappa$, $\partial\Pi_2(y_1,y_2)/\partial y_2 > 0$. Thus if the firms' reaches overlap, at least one of the two firms has an incentive to deviate until the distance between y_1

and y_2 is large enough such that $y_1 + \kappa \leq y_2 - \kappa$.

Step 2: Any pair of locations such that $y_i < \kappa$ can never be a subgame-perfect equilibrium. Suppose $y_1 < \kappa$, then a part of the reach of firm 1 lies outside $[0,1]$. Thus firm 1 can profitable deviate to $y_1 = \kappa$ to increase its profit. This either strictly increases monopoly profit or weakly increases monopoly profit and strictly increases competition profit. Suppose $y_2 < \kappa$, the reaches would overlap, which is excluded in the first step of this proof. Thus neither firm chooses a location $y_i < \kappa$. By symmetry, neither firm chooses a location $y_i > 1 - \kappa$.

Step 3: All remaining pairs of locations (y_1, y_2) such that $y_1 \in [\kappa, 1-\kappa]$ and $y_2 \in [\kappa, 1-\kappa]$ with $y_1 + \kappa \leq y_2 - \kappa$ are subgame-perfect equilibria. With each of these pairs of locations, firms receive the highest possible profit $\Pi_1 = \Pi_2 = (v - \kappa^2)2\kappa$. Thus neither firm has an incentive to deviate.

Subgame-perfect equilibria for $1/4 < \kappa \leq 1/2$

Assume $1/4 < \kappa \leq 1/2$. The proof proceeds in four steps: First, we show that any pair of locations (y_1, y_2) where the firms' reaches do not overlap (i.e., $y_1 + \kappa \leq y_2 - \kappa$) cannot be a subgame-perfect equilibrium. Second, we show that in the subgame-perfect equilibrium firms do not choose locations such that $y_1 > \kappa$ and/or $y_2 < 1 - \kappa$. Third, we show that firm 1 never chooses a location $y_1 < (y_2 - \kappa)/2$ and firm 2 never chooses a location $y_2 > (1 + y_1 + \kappa)/2$. Fourth, we specify the best replies and the subgame-perfect equilibria.

Step 1: Any pair of locations such that $y_1 + \kappa \leq y_2 - \kappa$ can never be a subgame-perfect equilibrium. Suppose $y_1 + \kappa \leq y_2 - \kappa$, then a part of the reach of at least one firm lies outside $[0,1]$. This firm can profitable deviate to increase its profit by forcing an overlap. This increases monopoly profit and competition profit. Therefore, firms always choose locations such that $y_1 + \kappa > y_2 - \kappa$.

Step 2: Firm 1 never chooses a location $y_1 > \kappa$. Suppose $y_1 > \kappa$,

$$\Pi_1(y_1, y_2) = (v - \kappa^2)(y_2 - y_1) + \frac{1}{18}(y_2 - y_1)(3y_2 - 4\kappa - 2\min\{y_1 + \kappa, 1\} - y_1)^2$$

$$\frac{\partial \Pi_1(y_1, y_2)}{\partial y_1} =$$

$$= \begin{cases} -\underbrace{v}_{>3} \underbrace{-\kappa^2 + 4\kappa(y_2 - y_1)}_{<8\kappa^2 - \kappa^2 < 3} \underbrace{-\frac{3}{2}(y_2 - y_1)^2}_{\leq 0} < 0 & \text{if } y_1 + \kappa < 1 \\ \underbrace{\kappa^2 - v}_{<0} - \underbrace{\frac{(3y_2 - y_1 - 4\kappa - 2)(5y_2 - 3y_1 - 4\kappa - 2)}{18}}_{>0} < 0 & \text{if } y_1 + \kappa \geq 1. \end{cases}$$

The first derivative is strictly negative and firm 1 always has an incentive to move to the left. Therefore, firm 1 never chooses a location $y_1 > \kappa$. By symmetry, firm 2 never chooses a location $y_2 < 1 - \kappa$. Consequently, a potential subgame-perfect equilibrium must involve $y_1 \leq \kappa$ and $y_2 \geq 1 - \kappa$.

Step 3: As $y_1 \leq \kappa$ and $y_2 \geq 1 - \kappa$ with $y_1 + \kappa > y_2 - \kappa$, both firms locate close to the boundaries of the product space but also compete for consumers who notice both firms in the center. Profits for both firms become

$$\begin{aligned}\Pi_1(y_1, y_2) =& \frac{1}{2}(y_2 - y_1)(y_2 - y_1 - 2\kappa)^2 \\ &+ (y_2 - \kappa)\begin{cases}(v - (y_2 - y_1 - \kappa)^2) & \text{if } y_1 < \frac{y_2-\kappa}{2} \\ (v - y_1^2) & \text{if } y_1 \geq \frac{y_2-\kappa}{2}\end{cases} \\ \Pi_2(y_1, y_2) =& \frac{1}{2}(y_2 - y_1)(y_2 - y_1 - 2\kappa)^2 \\ &+ (1 - y_1 - \kappa)\begin{cases}(v - (y_2 - y_1 - \kappa)^2) & \text{if } y_2 > \frac{1+y_1+\kappa}{2} \\ (v - (1 - y_2)^2) & \text{if } y_2 \leq \frac{1+y_1+\kappa}{2}\end{cases}\end{aligned}$$

First, suppose firm 1 would choose a location $y_1 < (y_2 - \kappa)/2$. As

$$\frac{\partial \Pi_1(y_1, y_2)}{\partial y_1} = 2\underbrace{(y_2 - y_1 - \kappa)}_{>0 \text{ as } y_1 < \frac{y_2-\kappa}{2}}\underbrace{(y_2 - \kappa)}_{>0} - \underbrace{\frac{3}{2}(y_2 - y_1 - 2\kappa)}_{<0}\underbrace{\left(y_2 - y_1 - \frac{2}{3}\kappa\right)}_{>0 \text{ as } y_1 < \frac{y_2-\kappa}{2}} > 0,$$

firm 1 always has an incentive to move inwards for $y_1 < (y_2 - \kappa)/2$. By symmetry, the same holds for firm 2 choosing $y_2 > (1 + y_1 + \kappa)/2$. Then, a potential subgame-perfect equilibrium must involve locations such that $y_1 \in [(y_2 - \kappa)/2, \kappa]$ and $y_2 \in [1 - \kappa, (1 + y_1 + \kappa)/2]$.

Step 4: Now, we derive the best replies of firm 1 and firm 2 with $y_1 \in [(y_2 - \kappa)/2, \kappa]$ and $y_2 \in [1-\kappa, (1+y_1+\kappa)/2]$ and, subsequently, specify the subgame-perfect equilibria. The first derivative of the profit functions of both firms is

$$\begin{aligned}\frac{\partial \Pi_1(y_1, y_2)}{\partial y_1} &= -2y_1(y_2 - \kappa) - \frac{3}{2}(y_2 - y_1 - 2\kappa)\left(y_2 - y_1 - \frac{2}{3}\kappa\right) = 0 \\ \Leftrightarrow y_1(y_2) &= \frac{1}{3}\left(y_2 - 2\kappa \pm 2\sqrt{-2y_2^2 + 5\kappa y_2 - 2\kappa^2}\right) \\ \frac{\partial \Pi_2(y_1, y_2)}{\partial y_2} &= 2(1 - y_2)(1 - y_1 - \kappa) + \frac{3}{2}(y_2 - y_1 - 2\kappa)\left(y_2 - y_1 - \frac{2}{3}\kappa\right) = 0 \\ \Leftrightarrow y_2(y_1) &= \frac{1}{3}\left(2 + y_1 + 2\kappa \pm 2\sqrt{-2y_1^2 + y_1(4 - 5\kappa) + \kappa(5 - 2\kappa) - 2}\right).\end{aligned}$$

Checking the second order condition, we find that the potential maxima are[19]

$$y_1(y_2) = \frac{1}{3}\left(y_2 - 2\kappa + 2\sqrt{-2y_2^2 + 5\kappa y_2 - 2\kappa^2}\right)$$
$$y_2(y_1) = \frac{1}{3}\left(2 + y_1 + 2\kappa - 2\sqrt{-2y_1^2 + y_1(4-5\kappa) + \kappa(5-2\kappa) - 2}\right).$$

Note that these potential maxima must fulfill the conditions $y_1 \in [(y_2-\kappa)/2, \kappa]$ and $y_2 \in [1-\kappa, (1+y_1+\kappa)/2]$ to be a best reply. For simplicity, let us first focus on the derivation of the best reply function for firm 1. Consequently, for $y_1 \in [(y_2-\kappa)/2, \kappa]$ we must have

$$\frac{y_2-\kappa}{2} \leq \frac{1}{3}\left(y_2 - 2\kappa + 2\sqrt{-2y_2^2 + 5\kappa y_2 - 2\kappa^2}\right) \leq \kappa.$$

If the best reply lies outside the range, the firm chooses the boundary solution. Checking both conditions we find that

$$y_1(y_2) = \begin{cases} \frac{y_2-\kappa}{2} & \text{if } y_2 < \frac{13-4\sqrt{3}}{11}\kappa \\ \frac{y_2-2\kappa+2\sqrt{-2y_2^2+5\kappa y_2-2\kappa^2}}{3} & \text{if } \frac{13-4\sqrt{3}}{11}\kappa \leq y_2 \leq \frac{13+4\sqrt{3}}{11}\kappa \\ \frac{y_2-\kappa}{2} & \text{if } y_2 > \frac{13+4\sqrt{3}}{11}\kappa. \end{cases} \tag{4}$$

Next, we need to check whether the conditions of (4) satisfy $[1-\kappa, (1+y_1+\kappa)/2]$ or are partly outside. First, we check

$$\frac{13-4\sqrt{3}}{11}\kappa \leq 1-\kappa \leq \frac{13+4\sqrt{3}}{11}\kappa$$
$$\frac{11}{24+4\sqrt{3}} \leq \kappa \leq \frac{11}{24-4\sqrt{3}} \tag{5}$$

The subgame-perfect equilibria are in the range of the best reply function, i.e., satisfying also the conditions for $(1+y_1+\kappa)/2$,. Using (4) and (5), we can rewrite the best reply function of firm 1:

If $\kappa < \frac{11}{24+4\sqrt{3}}$,

$$y_1^*(y_2) = \frac{y_2-\kappa}{2}.$$

[19]For firm 1 the potential maximum only exists if $y_2 \leq 2\kappa$. Suppose $y_2 > 2\kappa$, then $\partial\Pi_1(y_1,y_2)/\partial y_1 < 0$ and firm 1 chooses $y_1 = (y_2-\kappa)/2$. For firm 2 the potential maximum only exists if $y_1 \geq 1-2\kappa$. Suppose $y_1 < 1-2\kappa$, then $\partial\Pi_2(y_1,y_2)/\partial y_2 > 0$ and firm 2 chooses $y_2 = (1+y_1+\kappa)/2$.

If $\frac{11}{24+4\sqrt{3}} \leq \kappa \leq \frac{1}{2}$,

$$y_1^*(y_2) = \begin{cases} \frac{y_2 - 2\kappa + 2\sqrt{-2y_2^2 + 5\kappa y_2 - 2\kappa^2}}{3} & \text{if } y_2 \leq \frac{13+4\sqrt{3}}{11}\kappa \\ \frac{y_2 - \kappa}{2} & \text{if } y_2 > \frac{13+4\sqrt{3}}{11}\kappa \end{cases}$$

Checking the same conditions for firm 2, if $\kappa < \frac{11}{24+4\sqrt{3}}$,

$$y_2^*(y_1) = \frac{1 + y_1 + \kappa}{2}$$

and if $\frac{11}{24+4\sqrt{3}} \leq \kappa \leq \frac{1}{2}$,

$$y_2^*(y_1) = \begin{cases} \frac{1+y_1+\kappa}{2} & \text{if } y_1 < \frac{11-13\kappa-\sqrt{48}\kappa}{11} \\ \frac{2+y_1+2\kappa-2\sqrt{-2y_1^2+y_1(4-5\kappa)+\kappa(5-2\kappa)-2}}{3} & \text{if } \frac{11-13\kappa-\sqrt{48}\kappa}{11} \leq y_1 \leq \kappa \end{cases}$$

The intersections of the best replies gives the subgame-perfect equilibria.
Thus if $1/4 < \kappa \leq (7 - 3\sqrt{3})/4$, the subgame-perfect equilibrium locations are

$$y_1^* = \frac{1 - \kappa}{3}$$
$$y_2^* = \frac{2 + \kappa}{3}$$

and if $(7 - 3\sqrt{3})/4 < \kappa \leq 1/2$ the subgame-perfect equilibrium locations are

$$y_1^* = \frac{1}{4}\left(2 - 3\kappa + \sqrt{\kappa^2 + 4\kappa - 2}\right)$$
$$y_2^* = \frac{1}{4}\left(2 + 3\kappa - \sqrt{\kappa^2 + 4\kappa - 2}\right).$$

Subgame-perfect equilibria for $1/2 < \kappa \leq 1$

Assume $1/2 < \kappa \leq 1$, then $\kappa > 1 - \kappa$. Then, even if firms maximally differentiate their products, the firms' reaches will always overlap, i.e., $y_1 + \kappa > y_2 - \kappa$. The proof proceeds in three steps: First, we show that a pair (y_1, y_2) such that $y_1 > 1 - \kappa$ and/or $y_2 < \kappa$ cannot constitute a subgame-perfect equilibrium. Second, we show that firm 1 never chooses a location $y_1 < (y_2 - \kappa)/2$ and firm 2 never chooses a location $y_2 > (1 + y_1 + \kappa)/2$. Third, we specify the best replies and the subgame-perfect equilibria.

Step 1: Suppose $y_1 \geq 1-\kappa$ and $y_2 > \kappa$:

$$\Pi_1(y_1,y_2) = \frac{1}{18}(y_2-y_1)(3y_2-y_1-4\kappa-2)^2 + \begin{cases} (v-\kappa^2)(y_2-y_1) & \text{if } y_1 \geq \kappa \\ (v-y_1^2)(y_2-\kappa) & \text{if } y_1 < \kappa \end{cases}$$

$$\frac{\partial \Pi_1(y_1,y_2)}{\partial y_1} =$$

$$= \underbrace{\frac{1}{18}\underbrace{(3y_2-y_1-4\kappa-2)}_{<0 \text{ as } 4\kappa+2>3y_2}\underbrace{(-5y_2+3y_1+4\kappa+2)}_{>0 \text{ as } 3y_1+4\kappa+2>5y_2} + \begin{cases} \underbrace{-(v-\kappa^2)}_{<0} & \text{if } y_1 \geq \kappa \\ \underbrace{-2y_1(y_2-\kappa)}_{<0} & \text{if } y_1 < \kappa \end{cases}}_{<0}$$

Suppose $y_1 \geq 1-\kappa$ and $y_2 \leq \kappa$. Then,

$$\Pi_1(y_1,y_2) = \frac{1}{18}(y_2-y_1)(2+y_1+y_2)^2$$
$$\frac{\partial \Pi_1(y_1,y_2)}{\partial y_1} = \frac{1}{18}\underbrace{(2+y_1+y_2)}_{>0}\underbrace{(y_2-3y_1-2)}_{<0} < 0.$$

Therefore, firm 1 never chooses a location $y_1 > 1-\kappa$. Those locations are strictly dominated by $y_1 = 1-\kappa$. By symmetry, firm 2 never chooses a location $y_2 < \kappa$. Those locations are strictly dominated by $y_2 = \kappa$.

Step 2: Thus $y_1 \leq 1-\kappa$ and $y_2 \geq \kappa$. Consequently, the profits of firm 1 and firm 2 are

$$\begin{aligned}
\Pi_1(y_1,y_2) =& \frac{1}{2}(y_2-y_1)(y_2-y_1-2\kappa)^2 \\
&+ (y_2-\kappa)\begin{cases} (v-(y_2-y_1-\kappa)^2) & \text{if } y_1 < \frac{y_2-\kappa}{2} \\ (v-y_1^2) & \text{if } y_1 \geq \frac{y_2-\kappa}{2} \end{cases} \\
\Pi_2(y_1,y_2) =& \frac{1}{2}(y_2-y_1)(y_2-y_1-2\kappa)^2 \\
&+ (1-y_1-\kappa)\begin{cases} (v-(y_2-y_1-\kappa)^2) & \text{if } y_2 > \frac{1+y_1+\kappa}{2} \\ (v-(1-y_2)^2) & \text{if } y_2 \leq \frac{1+y_1+\kappa}{2} \end{cases}
\end{aligned}$$

The profit of firm 1 is strictly increasing for $y_1 < (y_2-\kappa)/2$ and the profit of firm 2 is strictly decreasing for $y_2 > (1+y_1+\kappa)/2$:

$$\frac{\partial \Pi_1(y_1,y_2)}{\partial y_1} = 2\underbrace{(y_2-y_1-\kappa)}_{>0 \text{ as } y_1<\frac{y_2-\kappa}{2}}\underbrace{(y_2-\kappa)}_{\geq 0}+\frac{3}{2}\underbrace{(y_1-y_2+2\kappa)}_{>0}\underbrace{(y_2-y_1-\frac{2}{3}\kappa)}_{>0 \text{ as } y_1<\frac{y_2-\kappa}{2}} > 0$$

$$\frac{\partial \Pi_2(y_1,y_2)}{\partial y_2} = 2\underbrace{(y_1-y_2+\kappa)}_{<0}\underbrace{(1-y_1-\kappa)}_{\geq 0}+\frac{3}{2}\underbrace{(y_2-y_1-2\kappa)}_{<0}\underbrace{(y_2-y_1-\frac{2}{3}\kappa)}_{>0 \text{ as } y_2>\frac{1+y_1+\kappa}{2}} < 0$$

Thus firm 1's optimal location has to be in the interval $[(y_2-\kappa)/2, 1-\kappa]$ and firm 2's optimal location has to be in the interval $[\kappa, (1+y_1+\kappa)/2]$.

Step 3: Next, we derive the best replies for firm 1 and firm 2 with $y_1 \in [(y_2-\kappa)/2, 1-\kappa]$ and $y_2 \in [\kappa, (1+y_1+\kappa)/2]$:

$$\begin{aligned}
\frac{\partial \Pi_1(y_1,y_2)}{\partial y_1} &= -2y_1(y_2-\kappa)-\frac{3}{2}(y_2-y_1-2\kappa)\left(y_2-y_1-\frac{2}{3}\kappa\right)=0\\
\Leftrightarrow y_1(y_2) &= \frac{1}{3}\left(y_2-2\kappa\pm 2\sqrt{-2y_2^2+5y_2\kappa-2\kappa^2}\right)\\
\frac{\partial \Pi_2(y_1,y_2)}{\partial y_2} &= 2(1-y_2)(1-y_1-\kappa)+\frac{3}{2}(y_2-y_1-2\kappa)\left(y_2-y_1-\frac{2}{3}\kappa\right)=0\\
\Leftrightarrow y_2(y_1) &= \frac{1}{3}\left(2+y_1+2\kappa\pm 2\sqrt{-2y_1^2+y_1(4-5\kappa)+\kappa(5-2\kappa)-2}\right).
\end{aligned}$$

Checking the second order condition, we find that the potential maxima are:

$$\begin{aligned}
y_1(y_2) &= \frac{1}{3}\left(y_2-2\kappa+2\sqrt{-2y_2^2+5y_2\kappa-2\kappa^2}\right)\\
y_2(y_1) &= \frac{1}{3}\left(2+y_1+2\kappa-2\sqrt{-2y_1^2+y_1(4-5\kappa)+\kappa(5-2\kappa)-2}\right).
\end{aligned}$$

But to be the best replies, the potential maxima have to lie inside the interval $[(y_2-\kappa)/2, 1-\kappa]$ and $[\kappa, (1+y_1+\kappa)/2]$. For firm 1:

$$\begin{aligned}
y_1(y_2)\leq 1-\kappa \Leftrightarrow y_2 &\leq \frac{1+3\kappa-2\sqrt{3\kappa-2}}{3} \text{ or } \frac{1+3\kappa+2\sqrt{3\kappa-2}}{3}\leq y_2\\
\frac{y_2-\kappa}{2}\leq y_1(y_2) \Leftrightarrow & \frac{13-\sqrt{48}}{11}\kappa \leq y_2 \leq \frac{13+\sqrt{48}}{11}\kappa.
\end{aligned}$$

In addition $y_2 \in [\kappa, (1+y_1+\kappa)/2]$. Therefore, the best reply of firm 1 is

- if $\kappa > \frac{3}{4}$: $y_1^*(y_2) = 1-\kappa$
- if $\frac{2}{3} < \kappa \leq \frac{3}{4}$:

$$y_1^*(y_2) = \begin{cases} \frac{1}{3}\left(y_2-2\kappa+2\sqrt{-2y_2^2+5y_2\kappa-2\kappa^2}\right) & \text{if } y_2 \leq \frac{1+3\kappa-2\sqrt{3\kappa-2}}{3}\\ 1-\kappa & \text{if } y_2 > \frac{1+3\kappa-2\sqrt{3\kappa-2}}{3}\end{cases}$$

- if $\frac{11}{13+\sqrt{48}} < \kappa \leq \frac{2}{3}$: $y_1^*(y_2) = \frac{1}{3}\left(y_2 - 2\kappa + 2\sqrt{-2y_2^2 + 5y_2\kappa - 2\kappa^2}\right)$
- if $\frac{1}{2} < \kappa \leq \frac{11}{13+\sqrt{48}}$:

$$y_1^*(y_2) = \begin{cases} \frac{1}{3}\left(y_2 - 2\kappa + 2\sqrt{-2y_2^2 + 5y_2\kappa - 2\kappa^2}\right) & \text{if } y_2 \leq \frac{13+\sqrt{48}}{11}\kappa \\ \frac{y_2-\kappa}{2} & \text{if } y_2 > \frac{13+\sqrt{48}}{11}\kappa. \end{cases}$$

Similarly, the best reply of firm 2 is, then,

- if $\kappa > \frac{3}{4}$: $y_2^*(y_1) = \kappa$
- if $\frac{2}{3} < \kappa \leq \frac{3}{4}$:

$$y_2^*(y_1) = \begin{cases} \kappa & \text{if } y_1 < \frac{2-3\kappa+2\sqrt{3\kappa-2}}{3} \\ \frac{2+y_1+2\kappa-2\sqrt{-2y_1^2+y_1(4-5\kappa)+\kappa(5-2\kappa)-2}}{3} & \text{if } y_1 \geq \frac{2-3\kappa+2\sqrt{3\kappa-2}}{3} \end{cases}$$

- if $\frac{11}{13+\sqrt{48}} < \kappa \leq \frac{2}{3}$: $y_2^*(y_1) = \frac{2+y_1+2\kappa-2\sqrt{-2y_1^2+y_1(4-5\kappa)+\kappa(5-2\kappa)-2}}{3}$
- if $\frac{1}{2} < \kappa \leq \frac{11}{13+\sqrt{48}}$:

$$y_2^*(y_1) = \begin{cases} \frac{1+y_1+\kappa}{2} & \text{if } y_1 < \frac{11-13\kappa-\sqrt{48}\kappa}{11} \\ \frac{2+y_1+2\kappa-2\sqrt{-2y_1^2+y_1(4-5\kappa)+\kappa(5-2\kappa)-2}}{3} & \text{if } y_1 \geq \frac{11-13\kappa-\sqrt{48}\kappa}{11}. \end{cases}$$

The intersections of the best replies gives the subgame-perfect equilibria.
Thus if $1/2 < \kappa \leq 3/4$, the subgame-perfect equilibrium locations are

$$\begin{aligned} y_1^* &= \frac{1}{4}\left(2 - 3\kappa + \sqrt{\kappa^2 + 4\kappa - 2}\right) \\ y_2^* &= \frac{1}{4}\left(2 + 3\kappa - \sqrt{\kappa^2 + 4\kappa - 2}\right) \end{aligned}$$

and if $3/4 < \kappa \leq 1$, the subgame-perfect equilibrium locations are $y_1^* = 1 - \kappa$ and $y_2^* = \kappa$.

4 Poverty and Limited Attention

Stefanie Y. Schmitt, Markus G. Schlatterer

Abstract

In this article, we analyze whether the financial strain of poverty systematically alters the allocation of attention. We address two types of attention: attention to unexpectedly occurring events and attention to primary tasks that require focus. We show that the poor are significantly more likely than the rich to notice unexpected events. In addition, we do not find robust evidence that poverty increases the likelihood of noticing the unexpected events at the expense of attention to the primary task.

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4.1 Introduction

Increasing evidence indicates that limited attention plays a major role in decision-making. For example, consumers do not fully attend to odometer mileage of used cars (Lacetera, Pope, and Sydnor, 2012; Busse, Lacetera, Pope, Silva-Risso, and Sydnor, 2013; Englmaier, Schmöller, and Stowasser, 2018), age of used cars (Englmaier, Schmöller, and Stowasser, 2018), shipping costs (Brown, Hossain, and Morgan, 2010), existing taxes (Chetty, Looney, and Kroft, 2009), or new tax rules (Abeler and Jäger, 2015).[20] Yet, few economic studies analyze whether individual differences in attention allocation exist. In this article, we investigate whether differences in attention allocation between the rich and the poor exist.

Specifically, we analyze whether poverty predicts attention allocation in inattentional blindness experiments. Inattentional blindness experiments consist of a primary task and an unexpected event that occurs during the primary task. Inattentional blindness "denotes the failure to see highly visible objects we may be looking at directly when our attention is elsewhere" (Mack, 2003). In these experiments, an individual is inattentional blind if, while focusing on the primary task, she does not notice the unexpected event. A famous experiment is the *invisible gorilla* (Simons and Chabris, 1999). In

[20] For an overview, see Gabaix (2019).

that experiment, subjects watch a video, in which two teams each pass a basketball. The primary task of subjects is to count how often one of the teams passes the basketball. In the middle of the video, a person dressed in a gorilla costume walks through the scene (the unexpected event). Although subjects look directly at the gorilla, a significant fraction of subjects fail to notice the gorilla.

Inattentional blindness has not only been demonstrated in abstract laboratory experiments. Inattentional blindness also prevails under realistic primary tasks. For example, radiologists looking at CTs fail to notice superimposed gorillas (Drew, Võ, and Wolfe, 2013) and drivers in simulators fail to notice pedestrians (Murphy and Greene, 2016). In addition, inattentional blindness has been demonstrated in field experiments: Cell phone users do not see a unicycling clown during a walk (Hyman Jr., Boss, Wise, McKenzie, and Caggiano, 2010) and running after another person leads to running past a fight without noticing the fight (Chabris, Weinberger, Fontaine, and Simons, 2011).

Inattentional blindness is an economically significant cognitive phenomenon. Depending on the situation, being inattentional blind can be problematic or beneficial. For example, inattentional blindness is problematic when drivers do not notice pedestrians, workers do not notice early signs of machine failure at their workplace, or medical staff do not notice unexpected complications in patients. In these cases inattentional blindness carries high economic costs. In addition, as inattentional blindness illustrates that not all information are processed even if they are freely available, the assumption of decision-making under full information is problematic. Without full information, the probability that individuals choose the utility-maximizing option decreases. For example, although very often information (such as whether the next payment will overdraft the account) is freely available, individuals do not attend to this information (Stango and Zinman, 2014). In addition, Hanna, Mullainathan, and Schwartzstein (2014) show in a field experiment that if individuals do not expect information to be relevant, they do not attend to this information and thus miss opportunities to increase profits. Inattentional blindness experiments capture these inattention problems in a more abstract way. Nevertheless, situations also exist where ignoring unexpected events is beneficial. For example, when facing tasks that require concentration, being able to ignore *irrelevant* distractions, such as noise from a nearby construction site or unwanted advertisements on a website, is beneficial.

A large literature in psychology tries to identify triggers of inattentional blindness. Most of the literature discusses triggers that are task dependent: for example, perceptual load, i.e., the difficulty of the primary task (see, e.g., Simons and Chabris, 1999; Cartwright-Finch and Lavie, 2007; Chabris, Weinberger, Fontaine, and Simons, 2011; Murphy and Greene, 2016), or similarity of the unexpected event to the targets in the primary task (see, e.g., Simons and Chabris, 1999; Most, Simons, Scholl, Jimenez, Clifford, and Chabris, 2001). However, independently of the task design, individuals differ in their susceptibility to inattentional blindness. One predictor for inattentional blindness, for instance, is the age of the individual (see, e.g., Graham and Burke, 2011; Stothart, Boot, and Simons, 2015; Horwood and Beanland, 2016). Overall, this literature shows that inattentional blindness varies between and within individuals. We contribute to this literature by proposing an additional heterogeneity, namely, that poverty reduces the likelihood of being inattentional blind.

Overall, understanding whether groups differ in the attention to new information is relevant for designing better policies. If some groups are less likely to notice new information, we can increase the salience to increase awareness of the information. For example, governmental programs, such as assistance or training programs, need to be perceived by those who are applicable for such programs. If the target group is unlikely to perceive new information, it is not sufficient for the government just to offer the program. In addition, the government needs to increase the salience of the program to the target group. Similarly, firms need to understand for advertising purposes whether consumers differ in their attention allocation. For example, if the rich are less likely to perceive unexpected events such as advertisements on websites, firms selling luxury products like expensive watches need to adjust their advertising strategies to make the advertisement more salient to their target group compared to firms selling everyday consumption goods.

In this article, we focus on analyzing whether the rich are more inattentional blind than the poor. One predictor for inattentional blindness is the load on working memory experienced by the subject during the experiment (de Fockert and Bremner, 2011): Load theory (Lavie and Tsal, 1994; Lavie, 1995; Lavie, Hirst, de Fockert, and Viding, 2004) argues that cognitive control functions, and working memory in particular, are necessary to focus attention on task-relevant information (see Murphy, Groeger, and Greene, 2016, for an overview of load theory). If working memory load is high, the ability to focus solely on the relevant information decreases and other information is processed as well. For example, a subject who has to count how often one team passes a basketball has to focus on that team's basketball passes. However, if that subject's working memory load is high, the subject does not focus fully on the basketball passes and, therefore, also notices the gorilla walking through the scene. Consequently, increased working memory load increases the probability of noticing unexpected events (de Fockert and Bremner, 2011). Evidence by Mani, Mullainathan, Shafir, and Zhao (2013) and Shah, Mullainathan, and Shafir (2012) indicates that poverty (or scarcity in general) reduces cognitive capacity, especially fluid intelligence,[21] and acts as a distraction that increases working memory load. Thus as poverty loads working memory

[21] Fluid intelligence is "the capacity to think logically and solve problems in novel situations" (Mani, Mullainathan, Shafir, and Zhao, 2013, p. 977).

and increased working memory load reduces inattentional blindness, poverty should reduce inattentional blindness. This is the main hypothesis we analyze in this article. In addition, inattentional blindness experiments allow us to measure focused attention. In inattentional blindness experiments, subjects perform a primary task that requires the subjects to focus on a set of targets. Thus the performance on the primary task also provides information about the attention of the subjects. Various economically relevant tasks require such attention: For example, reading, coding, monitoring jobs such as air traffic control, or assembly line jobs require focused attention. Yet, as attention is a limited resource and poverty is distracting (see, e.g., Shah, Mullainathan, and Shafir, 2012; Mani, Mullainathan, Shafir, and Zhao, 2013), we expect that the focus of the poor subjects is interrupted more often. If the poor exhibit systematically less focused attention, a poverty trap might result. If the poor's focus on tasks is systematically worse, they perform worse at jobs that require focused attention or are less attentive at further trainings for skill enhancements. In turn, they earn less which increases poverty. Whether the poor have systematically less focused attention is the second main hypothesis we analyze in this article.

To test these hypotheses we need data of an inattentional blindness experiment where subjects differ in income. One problem with inattentional blindness experiments is that each subject can only participate once. If subjects know that an unexpected event occurs during the experiment, subjects consciously look for this unexpected event. Thus it is difficult to compile a large data set. In addition, we need data that includes enough income variation. Typical laboratory experiments with students do not include enough income variation. However, initiated by Conley, Chabris, and Simons, the Innovation Sample of the German Socio-Economic Panel Study (SOEP-IS) includes an inattentional blindness experiment for a subset of the respondents from the 2014 wave (SOEP-IS Group, 2018). Overall, 1370 individuals participated in the experiment. In addition, the SOEP-IS is a representative sample of German households and, therefore, includes people with various different backgrounds and thus with various different income levels. Consequently, we use data from the SOEP-IS for our analysis.

In line with our hypothesis, we find evidence for a relationship between poverty and inattentional blindness. In addition, we also provide some evidence that the relationship between poverty and inattentional blindness is causal: Considering that people in Germany are often paid wages at the turn of the month, people are less financially strained after the turn of the month. Our hypothesis about the relationship between poverty and inattentional blindness then suggests that subjects exhibit more inattentional blindness after the turn of the month. We show that changes in inattentional blindness occur around the turn of the month: Subjects in our sample are on average more inattentional blind after the turn of the month.

In addition, we find evidence for a relationship between poverty and the performance in the primary task. However, these findings are not robust. In particular, we do not find evidence for a significant payday effect. One possible explanation for this could be that the task is too short and not difficult enough to detect an effect. Therefore, we restrict our sample to subjects with the most difficult tasks. For this subsample, the post-payday group performs significantly better at the primary task. However, these findings are not robust to a difference-in-differences estimation. Overall, our results thus indicate that poverty decreases inattentional blindness, but we do not find robust evidence that this occurs at the expense of performance in the primary task.

The remainder of the article is structured as follows: Section 4.2 discusses our contributions to the literature. Section 4.3 describes the data. Section 4.4 covers the analysis of the data and discusses the results. Section 4.5 examines the limitations of the data and Section 4.6 highlights policy implications and concludes.

4.2 Related literature

An increasing literature studies the causal effects of poverty on cognitive functions and the resulting consequences on decision-making. However, evidence is mixed. Mani, Mullainathan, Shafir, and Zhao (2013) show in a laboratory study and in a field experiment that poverty reduces cognitive capacity, in particular, fluid intelligence and cognitive control.[22] This is in line with evidence provided by Spears (2011) who finds that economic decision-making reduces cognitive capacity of poor people more than of rich people. In contrast, evidence also accumulates that finds no effect of scarcity on cognitive functions. Carvalho, Meier, and Wang (2016) compare performance on cognitive tests of individuals interviewed before payday with individuals interviewed after payday. Carvalho, Meier, and Wang (2016) find no effect on cognitive functions between the two groups.[23] Fehr, Fink, and Jack (2019) analyze whether cognitive skills vary with scarcity in a sample of Zambian farmers. Notably, Fehr, Fink, and Jack (2019) utilize multiple sources of scarcity—cross sectional, seasonal, and randomized variation—and are able to address learning effects. They find no clear evidence for a negative effect of scarcity on cognitive skills. Dalton, Nhung, and Rüschenpöhler (2020)

[22]Mani, Mullainathan, Shafir, and Zhao (2013) show that poverty reduces the performance at Raven's matrices, a spatial compatibility task, and the Stroop task. The Raven's matrix measures fluid intelligence (see, e.g., Mani, Mullainathan, Shafir, and Zhao, 2013; Dean, Schilbach, and Schofield, 2019). Fluid intelligence is "the capacity to think logically and solve problems in novel situations" (Mani, Mullainathan, Shafir, and Zhao, 2013, p. 977). The spatial compatibility task and the Stroop task measure cognitive (Mani, Mullainathan, Shafir, and Zhao, 2013) or inhibitory control (Dean, Schilbach, and Schofield, 2019). "**Inhibitory control** is the ability to control impulses and minimize interference from irrelevant stimuli" (Dean, Schilbach, and Schofield, 2019, p. 61). Furthermore, working memory and inhibitory control are closely intertwined and are often not distinguished in the literature (Dean, Schilbach, and Schofield, 2019).

[23]Using the same data as Carvalho, Meier, and Wang (2016), Mani, Mullainathan, Shafir, and Zhao (2020) also analyze payday effects.

find an effect on risk aversion but not on cognitive performance. In addition, Lichand and Mani (2020) find evidence that income uncertainty affects cognitive functions of all subjects, but that expected income variation only has an effect for the poorest subjects. Shah, Zhao, Mullainathan, and Shafir (2018) show that poorer individuals are more likely to think about the costs associated with an experience. In addition, these thoughts about costs arise spontaneously and are persistent. In addition, Shah, Mullainathan, and Shafir (2012, 2019) provide evidence that subjects with scarce resources focus more on problems related to scarcity than subjects who do not face scarcity. Zhao and Tomm (2017) confirm this finding in an eye-tracking study. This increased focus on problems of scarcity might explain the increased load on cognitive functions. This increased load is problematic for tasks that require cognitive capacity: Shah, Mullainathan, and Shafir (2012, 2019) find that the greater engagement of poorer subjects results in neglect of the future and overborrowing and Kaur, Mullainathan, Oh, and Schilbach (2019) show that scarcity reduces productivity and increases error rates at work. Yet, (perceived) scarcity can also lead to better decision-making because the increased focus reduces context effects (Shah, Shafir, and Mullainathan, 2015) and endowment effects (Fehr, Fink, and Jack, 2019). In addition, at tasks that require proceduralized processes, such as typewriting, i.e., where too much attention to a task is detrimental, poorer subjects preform better (Dang, Xiao, Zhang, Liu, Jiang, and Mao, 2016).

We contribute to this literature in three ways. First, the scarcity literature argues that attention is a major driver behind these results. That is, poorer subjects focus more on problems related to their financial problems and neglect other problems. Yet, little research directly focuses on differences in attention allocation between the rich and the poor. One first step in the direction of analyzing whether attention differences between the rich and the poor exist is Goldin and Homonoff (2013) who show that the poor pay more attention to taxes than the rich. Lichand and Mani (2020) focus on trade-offs between money and goods. Bartoš, Bauer, Chytilová, and Levely (2018) measure sustained attention and find no effect of priming people to think of hard financial problems on sustained attention (number of inspected options, decision time, and likelihood to stay at default option). Zhao and Tomm (2017) analyze the attention of subjects to additional information that helps subjects in their primary task. Zhao and Tomm (2017) find that subjects experiencing scarcity use the additional information less if the information is presented away from the center of the spatial focus but not too far away. In general, this literature focuses on attention to expected events and/or on attention to events related to the financial burdens of poverty. Furthermore, to trigger a scarcity mindset, studies often use priming. In contrast, we analyze the attention allocation more abstractly. The task is unrelated to the financial difficulties of the subjects. Yet, we find attention differences between the rich and the poor, without priming the subjects. Furthermore, we are the first to analyze the relationship between poverty and attention to unexpected events in a classical inattentional blindness experiment. Understanding the relationship between poverty and attention to unexpected events is relevant to understand whether people notice new goods or government programs on their own or whether we have to increase effort (e.g., salience or advertising) such that the relevant individuals notice these goods and programs.

Second, we also contribute to the debate that questions the transferability of the results of the scarcity literature from absolute poverty to relative poverty in developed countries. Although Mani, Mullainathan, Shafir, and Zhao (2013) argue that the consequences of scarcity are not limited to developing countries, doubt remains whether these findings are transferable to developed countries. For example, Lichand and Mani (2020) find a payday effect only for the poorest subjects in their sample of Brazilian farmers and Carvalho, Meier, and Wang (2016) find no payday effect in a sample of American households. We study the effects of relative poverty on attention in a sample of German households. Our results provide evidence for differences in attention allocation between the rich and the poor. We thus add to the debate by providing further evidence for an effect of scarcity also in developed countries.

Third, we also add to the literature that analyzes the relationship between poverty and focused attention, which we measure as the number of errors subjects make during their task. In contrast to Kaur, Mullainathan, Oh, and Schilbach (2019), we do not find a robust relationship between poverty and error rates. That is, the poor in the SOEP-IS experiment are not less inattentional blind at the expense of performance in the primary task. The difference to the results of Kaur, Mullainathan, Oh, and Schilbach (2019) could stem from a variety of factors, such as the difference in task. For instance, the subjects in Kaur, Mullainathan, Oh, and Schilbach (2019) were doing a real-world task for the whole day, while the SOEP-IS experiment lasted only 17 seconds. Maybe if the task in the experiment took longer, the differences in error rates would be more pronounced. This explanation is plausible because we find an effect if we restrict the sample to subjects with the most difficult task. However, this effect is not robust to a difference-in-differences estimation.

4.3 Data

We use data from the Innovation Sample of the German Socio-Economic Panel Study (SOEP-IS, Richter and Schupp, 2015; Goebel, Liebig, Richter, Schröder, Schupp, and Wenzig, 2020). The SOEP-IS exists since 2011 and includes changing questionnaires and behavioral experiments. In 2014, on the initiative of Conley, Chabris, and Simons the SOEP-IS included an experiment on inattentional blindness with 1370 participants

(SOEP-IS Group, 2018; Bohlender and Glemser, 2016). By using this data set, we avoid a common problem of inattentional blindness research. When testing for inattentional blindness, one can only test each individual once. As soon as subjects know that an unexpected event occurs, subjects consciously look for an unexpected event in subsequent rounds and are thus more likely to notice an unexpected event. Consequently, many inattentional blindness experiments have only few subjects.[24] One advantage of the SOEP-IS data set is the large number of participants in the experiment. In addition, in contrast to classical laboratory experiments of inattentional blindness, where students are the majority of subjects, the SOEP-IS is a representative sample of German households and thus provides more variation in, for example, household income and age of respondents.

In the SOEP-IS inattentional blindness experiment (Bohlender and Glemser, 2016), subjects watch a video with black and white squares and circles moving around. The primary task consists of counting how often specific objects touch the frame of the video. Subjects are randomly assigned to one of four groups that count how often (i) the squares, (ii) the circles, (iii) the white, or (iv) the black shapes touch the frame of the video.[25] During this task, an unexpected event—an additional black circle—moves through the frame from right to left (see Figure 8).[26]

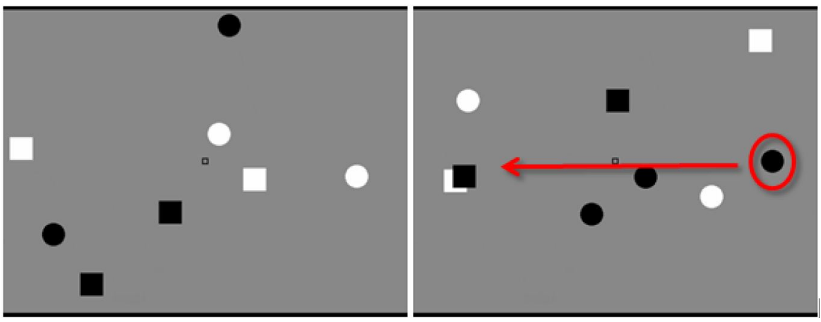

FIGURE 8: Illustration of the inattentional blindness experiment (source: Bohlender and Glemser, 2016).

After watching the video, respondents report their counts in the primary task. We drop the data of respondents who do not report their counts in the primary task. Afterwards, the interviewer asks if the respondents noticed an unexpected event that was not present at the start of the video. We drop the data of respondents who do not answer this question. If respondents affirm this question, they have to state the

[24]For example, in Most, Simons, Scholl, Jimenez, Clifford, and Chabris (2001) between 33 and 145 individuals and in Cartwright-Finch and Lavie (2007) between 39 and 57 individuals participated in the experiments.

[25]In the final sample with 1084 respondents, 258 respondents count squares, 265 respondents count circles, 290 respondents count white, and 271 respondents count black shapes.

[26]Such inattentional blindness experiments are common in the literature. For similar experiments, see, for example, Most, Simons, Scholl, Jimenez, Clifford, and Chabris (2001) or Stothart, Boot, and Simons (2015).

color, the shape, and the direction of movement of this object. Following Most, Simons, Scholl, Jimenez, Clifford, and Chabris (2001) and Stothart, Boot, and Simons (2015), we use these additionally reported characteristics to test whether the respondents really observed the unexpected event. If respondents answered that they did not notice the unexpected event or if they answered that they did notice the unexpected event but were unable to state at least one of its characteristics correctly, we define them as inattentional blind (IB=1).

As a test for the respondents' accuracy in the primary counting task, we use the relative counting error (|Counts - True Contacts|/True Contacts). We drop the data of the 5% of respondents who performed the worst in the counting task. This corresponds to respondents with a relative counting error of at least 80%. Such a high relative counting error suggests that the respondents did not understand their task in the experiment. The interviewers' assessment of the respondents' comprehensibility of the experiment provides evidence for this. Interviewers rated comprehensibility as very good, good, intermediate, bad, very bad, or unsatisfactory. This assessment is highly correlated with the relative counting error. Although the interviewers rated the comprehensibility of only 8.76% of the 1243 respondents[27] as bad, very bad, or unsatisfactory, the interviewers rated the comprehensibility of 26.98% of the 5% with the worst relative counting error as bad, very bad, or unsatisfactory.

The data set provides information about the monthly household net income of subjects as well as household size. We drop all observations without income data which leaves us with 1084 observations (562 female, 522 male). To address the concern that dropping respondents leads to selection into the sample, we test in 4.7.1 whether individual characteristics predict sample participation. Table 13 shows that only age predicts sample participation. Thus in our analysis, we include age (as well as gender and education) in the control vector.

Table 1 contains descriptive statistics on the main characteristics of respondents. The mean age in this sample is 50.29 with a range from 17 to 89. The mean household income in our sample is 2575.54 Euro with a median of 2300 Euro. The lowest reported monthly net household income is 300 Euro; the highest reported net household income is 10 000 Euro. The mean household size is 2.28 with a median of 2. Household size ranges from 1 to 9 individuals. We follow Mani, Mullainathan, Shafir, and Zhao (2013) in their definition of poverty: We compute effective household income by dividing the household net income by the square root of the number of individuals in the household and use a median split to define the poverty dummy variable. To check the robustness of our results, we use logarithmic effective household income.

[27] After dropping the data of respondents who did not report their counts in the primary task and who did not answer the question whether they noticed an unexpected event, our sample includes 1243 respondents.

Table 1: Descriptive statistics.

Variable	Mean	Median	Std.Dev.	Min	Max
Age	50.29	51	17.72	17	89
Monthly household net income in Euro	2575.54	2300	1455.12	300	10000
Household size	2.28	2	1.21	1	9
Monthly effective household income in Euro	1762.88	1555.64	948.49	257.5	10000
Relative counting error	0.36	0.33	0.20	0	0.79
Inattentional blindness	0.75	1	0.44	0	1

4.4 Results

Our objective is to investigate whether a relationship between poverty and attention allocation exists. In Section 4.4.1, we focus on the effect of poverty on inattentional blindness. In Section 4.4.2, we analyze the performance of the poor and the rich in the primary task.

4.4.1 Poverty and inattentional blindness

We divide our analysis of the effects of poverty on inattentional blindness into two parts. In Section 4.4.1.1, we compare the prevalence of inattentional blindness for the poor and the rich. To provide evidence for a causal effect of poverty on inattentional blindness, in Section 4.4.1.2, we analyze payday effects.

4.4.1.1 Differences in inattentional blindness between the rich and the poor

Our main objective is to investigate whether the poor and the rich differ in their inattentional blindness. As monetary concerns should increase the working memory load and, therefore, decrease the exclusive focus on the targets of the primary task, the poor should be more likely to notice the unexpected event and, consequently, should be less inattentional blind. In line with this first hypothesis, we find that the poor (mean $M = .720$; standard deviation $SD = .450$) are less likely to be inattentional blind than the rich ($M = .773; SD = .419$) (one-tailed $t(1082) = 2.03$; $p = .022$).
We analyze the effect of poverty on inattentional blindness in more detail. Table 2 provides the estimates of the effect of poverty on inattentional blindness. The results

show that the poor are less likely to be inattentional blind than the rich: In particular, in the baseline specification, the poor are 5.4 percentage points less likely to be inattentional blind than the rich. The literature on inattentional blindness indicates that the difficulty of the primary task (see, e.g., Lavie, 1995; Cartwright-Finch and Lavie, 2007) and the similarity of the unexpected event to the targets in the primary task (see, e.g., Simons and Chabris, 1999; Most, Simons, Scholl, Jimenez, Clifford, and Chabris, 2001) influence inattentional blindness. To rule out that these effects drive our results, we control in column (2) for the primary task of the respondents, i.e., whether the respondents count squares, circles, white, or black shapes. Our results are robust to these additional controls.

Including personal characteristics changes the estimate slightly. The specification with all controls in column (3) shows that poverty significantly decreases inattentional blindness by 7.7 percentage points. The estimates in column (4) are the result of a logit regression. The effect of poverty on inattentional blindness remains highly significant: Poor subjects have a, on average, 0.421 smaller estimated logarithmic chance of inattentional blindness. As a robustness check, we use different definitions of poverty (effective household income below a threshold of 60% and below a threshold of 50% of the median) and logarithmic effective household income instead of poverty as the independent variable (see 4.7.2). Our results are robust to this change in the specification.

TABLE 2: The effect of poverty on inattentional blindness.

	(1)	(2)	(3)	(4)
Poverty	-0.054^{**}	-0.055^{**}	-0.077^{***}	-0.421^{***}
	(0.026)	(0.026)	(0.028)	(0.151)
Experimental controls	-	Yes	Yes	Yes
Person controls	-	-	Yes	Yes
Constant	0.773^{***}	0.821^{***}	0.815^{***}	1.497^{***}
	(0.018)	(0.027)	(0.039)	(0.229)
N	1084	1084	1075	1075
R^2	0.004	0.016	0.041	0.037

Notes: (1), (2), and (3) are OLS estimates, (4) reports the estimates of a logit regression (the reported R^2 here is the corresponding Pseudo R^2) of poverty (=1 if subject is poor) on inattentional blindness (dependent variable=1 if subject is inattentional blind). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4.1.2 Payday effects on inattentional blindness

Section 4.4.1.1 shows that a relationship between poverty and inattentional blindness exists. To provide evidence for a causal effect of poverty on inattentional blindness, we follow Mani, Mullainathan, Shafir, and Zhao (2013), Carvalho, Meier, and Wang (2016), and Lichand and Mani (2020) in using the timing of the experiment as exogenous variation. A respondent who is interviewed after his payday should be relatively richer than if he would be interviewed before his payday. Thus post-payday, having just received money, a respondent should be less worried about his financial situation and his cognitive load should be lower. Therefore, we hypothesize that respondents who are interviewed after their payday are more inattentional blind than respondents who are interviewed pre-payday. Unfortunately, our sample does not include precise data about the individuals' paydays. However, in Germany, payday is often the last bank working day of the month. Therefore, we assume that the payday of each respondents is the last of each month and correct the payday to the previous bank working day if the last of the month is a holiday or a weekend.[28] We compare respondents who were interviewed in the (a) 8 days, (b) 7 days, (c) 6 days, (d) 5 days, (e) 4 days, (f) 3 days, (g) 2 days, and (h) 1 day period after the payday with the remaining sample. We exclude the data of respondents who were interviewed on the payday. In addition, we restrict our sample to the employed subjects.[29]

Table 3 shows the estimates for different post-payday periods (independent variable=1 if the subject was interviewed post-payday) for inattentional blindness (dependent variable=1 if the subject is inattentional blind). For example, in panel (a) we estimate the effect of having been interviewed within 8 days after the payday—so either on day 1, day 2, day 3, day 4, day 5, day 6, day 7, or day 8 after the payday—on inattentional blindness. Our sample includes interviews from September 2014 to April 2015. As financial demands might differ between weekdays or months—for instance, expenditures might increase close to Christmas—we control in column (2) for the day of the week and the month of the interview. Column (3) adds experimental controls, i.e., whether respondents count circles, squares, black, or white shapes. In column (4), we furthermore control for person characteristics (age, gender and, education). Column (5) provides the estimates of a logit regression with all controls.

Table 3 provides evidence for a payday effect. First of all, as predicted, all signs of the estimates are positive. That means, respondents interviewed after the payday show higher levels of inattentional blindness compared to the rest of the sample for all specifications. Second, this effect is significant for the period between the payday and 3 to 6 days after the payday for all specifications. For those respondents within the post-payday range in column (4) the estimated probabilities of showing inattentional blindness range from 7.4 to 24.9 percentage points and, therefore, are higher compared

[28]We discuss this assumption in more detail in Section 4.5.

[29]We drop subjects who are in education, pensioners, self-employed, free-lancers, help in family business, not employed, unemployed, or whose employment status is unknown. Consequently, our payday sample necessarily is selected. However, Table 14 in 4.7.1 shows that otherwise the observable characteristics of the two groups are balanced.

Table 3: The effect of post-payday on inattentional blindness.

	(1)	(2)	(3)	(4)	(5)
(a) 8 days post-payday	0.053	0.071	0.078	0.074	0.417
$N_{post-payday} = 80$	(0.051)	(0.058)	(0.057)	(0.057)	(0.33)
R^2	0.002	0.037	0.063	0.089	0.078
(b) 7 days post-payday	0.083	0.095	0.098	0.092	0.555
$N_{post-payday} = 66$	(0.053)	(0.06)	(0.059)	(0.059)	(0.366)
R^2	0.004	0.038	0.064	0.09	0.079
(c) 6 days post-payday	0.153***	0.178***	0.186***	0.179***	1.238**
$N_{post-payday} = 53$	(0.051)	(0.057)	(0.057)	(0.058)	(0.488)
R^2	0.011	0.046	0.073	0.098	0.088
(d) 5 days post-payday	0.191***	0.234***	0.247***	0.249***	2.008**
$N_{post-payday} = 33$	(0.054)	(0.057)	(0.06)	(0.063)	(0.816)
R^2	0.011	0.048	(0.075)	0.102	0.093
(e) 4 days post-payday	0.162**	0.212***	0.231***	0.223***	1.698**
$N_{post-payday} = 26$	(0.066)	(0.069)	(0.071)	(0.075)	(0.825)
R^2	0.006	0.043	0.071	0.096	0.086
(f) 3 days post-payday	0.145**	0.181**	0.191**	0.175**	1.317*
$N_{post-payday} = 23$	(0.073)	(0.075)	(0.076)	(0.078)	(0.785)
R^2	0.005	0.04	0.066	0.092	0.081
(g) 2 days post-payday	0.096	0.121	0.129	0.096	0.732
$N_{post-payday} = 17$	(0.095)	(0.102)	(0.104)	(0.107)	(0.841)
R^2	0.002	0.036	0.062	0.087	0.077
(h) 1 day post-payday	0.173*	0.118	0.115	0.079	0.735
$N_{post-payday} = 10$	(0.097)	(0.114)	(0.122)	(0.127)	(1.209)
R^2	0.003	0.035	0.061	0.087	0.076
N	516	516	516	516	516
Dummies for weekday	-	Yes	Yes	Yes	Yes
Dummies for month	-	Yes	Yes	Yes	Yes
Experimental controls	-	-	Yes	Yes	Yes
Person controls	-	-	-	Yes	Yes

Notes: (1),(2),(3), and (4) are OLS estimates, (5) are estimates from a logit regression (the reported R^2 here is the corresponding Pseudo R^2) with coefficient of (a) 8, (b) 7, (c) 6, (d) 5, (e) 4, (f) 3, (g) 2, and (h) 1 days post-payday (=1 if subject is interviewed post-payday) on inattentional blindness (dependent variable=1 if subject is inattentional blind). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person characteristics include age (centered), gender, and education (casmin) dummies. Robust standard errors in parenthesis. $^{*}p < 0.10,^{**} p < 0.05,^{***} p < 0.01$

to the rest of the sample. This is robust for the estimated logarithmic chances in column (5) as well. Shorter time periods fail to show significant results due to the small number of subjects within those periods, especially in the presence of controls. For example, only 10 people were interviewed one day after the payday and 17 in the two days after the payday (see Figure 9).

One concern is that these differences in inattentional blindness around the turn of the month are not the result of the financial situation, but of some other events that coincide with the turn of the month. If our results were indeed driven by some other event, then inattentional blindness is likely to differ around the turn of the month for all subjects, not just the employed. Therefore, to address this concern, we also compare the inattentional blindness of the respondents that we dropped because they are not employed. Table 4 shows the estimates for different post-payday periods for inattentional blindness for those respondents that we dropped because they are not employed. We do not find significant effects for this group of respondents.

These results are in line with the difference-in-differences estimates reported in Table 5. Column (1) of Table 5 shows the difference in mean inattentional blindness between the employed individuals in the post-payday group, i.e., who participated in the experiment in the (a) 8, (b) 7, (c) 6, (d) 5, (e) 4, (f) 3, (g) 2, or (h) 1 day period after the payday, and the employed individuals who participated in the experiment on one of the other days. Column (2) shows these difference in the group of individuals who are not employed. Column (3) reports the difference-in-differences estimates. In line with our hypothesis, for the employed, the difference over time is positive. That means, inattentional blindness is higher in the post-payday group. This difference is significant for the period between the payday and the 3 to 6 days after the payday. In contrast, the difference over time of the group of individuals who are not employed is generally smaller and never significantly different from zero. Our hypothesis implies that the difference over time of the employed is larger than the difference over time of the not employed. In line with this hypothesis, the difference-in-differences estimates in column (3) are generally positive (except for the 8-day range). We find the largest effects for the 5 and 6 days post-payday range. These effects are also significant. Together, these results indicate that the differences in inattentional blindness that we observe for the employed subjects in Table 3 are really the result of a payday effect.

The post-payday effects show that the differences in inattentional blindness are not determined by personal traits that are correlated with lower income, but that the current financial situation of the individuals influences inattentional blindness. As a robustness check we restrict our sample to symmetric ranges around the payday (see Table 20 in the Appendix). This reduces the sample size. For example, when we compare the respondents who were interviewed one day before payday with those interviewed one day after payday, our sample includes only 34 respondents. Nevertheless, all our

Table 4: Placebo-Test of the effect of post-payday on inattentional blindness.

	(1)	(2)	(3)	(4)	(5)
(a) 8 days post-payday	0.055	0.049	0.047	0.047	0.308
$N_{post-payday} = 107$	(0.043)	(0.05)	(0.05)	(0.051)	(0.322)
R^2	0.003	0.032	0.04	0.084	0.082
(b) 7 days post-payday	0.045	0.055	0.051	0.052	0.324
$N_{post-payday} = 88$	(0.047)	(0.052)	(0.052)	(0.052)	(0.333)
R^2	0.002	0.032	0.04	0.084	0.082
(c) 6 days post-payday	0.035	0.029	0.022	0.015	0.097
$N_{post-payday} = 70$	(0.052)	(0.058)	(0.058)	(0.057)	(0.371)
R^2	0.001	0.031	0.039	0.082	0.08
(d) 5 days post-payday	0.07	0.069	0.062	0.037	0.278
$N_{post-payday} = 48$	(0.057)	(0.062)	(0.062)	(0.061)	(0.459)
R^2	0.002	0.032	0.04	0.083	0.081
(e) 4 days post-payday	0.055	0.062	0.051	0.035	0.251
$N_{post-payday} = 39$	(0.064)	(0.069)	(0.069)	(0.067)	(0.485)
R^2	0.001	0.032	0.039	0.083	0.08
(f) 3 days post-payday	0.013	0.013	0.004	0.005	0.042
$N_{post-payday} = 32$	(0.076)	(0.08)	(0.08)	(0.078)	(0.503)
R^2	0.000	0.031	0.038	0.082	0.08
(g) 2 days post-payday	0.004	-0.003	-0.009	-0.024	-0.161
$N_{post-payday} = 22$	(0.091)	(0.099)	(0.103)	(0.102)	(0.645)
R^2	0.000	0.031	0.038	0.082	0.08
(h) 1 day post-payday	0.122	0.01	0.008	-0.01	0.016
$N_{post-payday} = 9$	(0.107)	(0.118)	(0.125)	(0.124)	(1.168)
R^2	0.001	0.031	0.038	0.082	0.08
N	546	546	546	537	537
Dummies for weekday	-	Yes	Yes	Yes	Yes
Dummies for month	-	Yes	Yes	Yes	Yes
Experimental controls	-	-	Yes	Yes	Yes
Person controls	-	-	-	Yes	Yes

Notes: (1),(2),(3), and (4) are OLS estimates, (5) are estimates from a logit regression (the reported R^2 here is the corresponding Pseudo R^2) with coefficient of (a) 8, (b) 7, (c) 6, (d) 5, (e) 4, (f) 3, (g) 2, and (h) 1 days post-payday (=1 if subject is interviewed post-payday) on inattentional blindness (dependent variable=1 if subject is inattentional blind). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person characteristics include age (centered), gender, and education (casmin) dummies. Robust standard errors in parenthesis. $^{*}p < 0.10,^{**} p < 0.05,^{***} p < 0.01$

Table 5: The effect of post-payday on inattentional blindness: difference-in-differences results.

	(1) Employed	(2) Not employed	(3) Difference in differences
(a) 8 days post-payday			
Difference over time	0.056	0.062	−0.007
	(0.054)	(0.047)	(0.067)
(b) 7 days post-payday			
Difference over time	0.088	0.053	0.035
	(0.055)	(0.05)	(0.07)
(c) 6 days post-payday			
Difference over time	0.159***	0.034	0.125*
	(0.056)	(0.055)	(0.074)
(d) 5 days post-payday			
Difference over time	0.212***	0.07	0.143*
	(0.06)	(0.059)	(0.081)
(e) 4 days post-payday			
Difference over time	0.189***	0.055	0.133
	(0.073)	(0.065)	(0.094)
(f) 3 days post-payday			
Difference over time	0.144*	0.014	0.131
	(0.077)	(0.076)	(0.105)
(g) 2 days post-payday			
Difference over time	0.07	−0.006	0.077
	(0.103)	(0.097)	(0.132)
(h) 1 day post-payday			
Difference over time	0.048	0.025	0.023
	(0.120)	(0.119)	(0.161)
N	516	537	

Notes: The table reports the estimates of the differences over time in inattentional blindness (dependent variable=1 if subject is inattentional blind) in the group of the employed and in the group of the not employed and the difference-in-differences estimates. The reported difference over time is the difference between the individuals interviewed (a) 8, (b) 7, (c) 6, (d) 5, (e) 4, (f) 3, (g) 2, or (h) 1 days post-payday and those individuals interviewed on some other day. Controls include dummies for weekday and month, experimental controls, i.e., whether the subject counts squares, circles, white, or black shapes, and person controls, i.e., age (centered), gender, and education (casmin) dummies. Robust standard errors in parenthesis. $^{*}p < 0.10,^{**} p < 0.05,^{***} p < 0.01$

estimates (except four where we have only few observations) have the predicted sign. Due to the smaller sample, however, the estimates are not as precise.

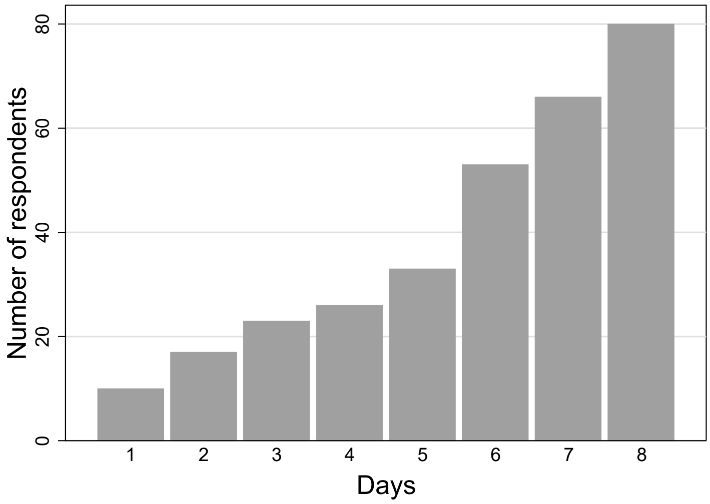

FIGURE 9: Number of respondents in the post-payday group.

4.4.2 Poverty and relative counting error

To address the question whether the lower inattentional blindness of the poor comes at the expense of focused attention, we compare the performance of the poor and the rich in the primary task of the inattentional blindness experiment. To measure performance, we use the relative counting errors: |Counts - True Contacts|/True Contacts.

4.4.2.1 Differences in relative counting errors between the rich and the poor

We hypothesize that the poor count more often incorrectly, thus showing higher relative errors. The comparison of the means in terms of the relative counting errors shows that the poor ($M = .369; SD = .203$) count more often incorrectly than the rich ($M = .345$; $SD = .2$). This result is significant on a 5% level (one-tailed $t(1082) = -1.943$; $p = .026$).

The results in Table 6 show that the effect of poverty on the relative counting errors is not robust in the presence of controls. While poverty increases the relative errors by 2.4 percentage points without further controls, we see no significant effect in column (3), where we control for task, age (centered), gender, and education. The significant results in the absence of these controls seem to refer to the correlation of income and those person characteristics. However, our robustness check where we use a continuous income variable, i.e., logarithmic household income, instead of the median split as the independent variable, increases the precision of our estimates (see Table 7).

This suggests that we lose too much information with a median split compared to the continuous income variable. To test this further, we split our sample into six groups. The poor groups contain the subjects with the lowest effective household income in 10% steps. *Poor 10%* contains the respondents with the 10% lowest effective household income, *Poor 10% - 20%* (*Poor 20% - 30%*, *Poor 30% - 40%*, *Poor 40% - 50%*) contains the respondents with effective household incomes in the range of 10% to 20% (20% to 30%, 30% to 40%, 40% to 50%). The 50% highest effective household income group is the reference category (see Table 8). In line with Kaur, Mullainathan, Oh, and Schilbach (2019), who find that their results are driven by the poorest subjects, we find a significant effect of the poorest 10% in our sample on the relative errors.[30]

TABLE 6: The effect of poverty on relative counting errors.

	(1)	(2)	(3)
Poverty	0.024*	0.026**	0.015
	(0.012)	(0.012)	(0.012)
Experimental controls	-	Yes	Yes
Person controls	-	-	Yes
Constant	0.345***	0.379***	0.379***
	(0.009)	(0.011)	(0.016)
N	1084	1084	1075
R^2	0.004	0.081	0.155

Notes: (1), (2), and (3) are OLS estimates with the coefficient of poverty (=1 if subject is poor) for relative counting errors (dependent variable). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

[30] As an additional robustness check, we use different definitions of poverty (effective household income below a threshold of 60% and below a threshold of 50% of the median). Results are in line with the finding in this section (see 4.7.2.3).

TABLE 7: The effect of logarithmic effective household income on relative counting errors.

	(1)	(2)	(3)
Log effective household income	-0.029^{**}	-0.032^{***}	-0.023^{*}
	(0.013)	(0.012)	(0.013)
Experimental controls	-	Yes	Yes
Person controls	-	-	Yes
Constant	0.571^{***}	0.624^{***}	0.551^{***}
	(0.092)	(0.088)	(0.094)
N	1084	1084	1075
R^2	0.005	0.083	0.157

Notes: (1), (2), and (3) are OLS estimates of the effect of logarithmic effective household income on relative counting errors (dependent variable). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

TABLE 8: The effect of the lowest effective household income groups on relative counting errors.

	(1)	(2)	(3)
Poor 10%	0.043^{*}	0.044^{**}	0.041^{*}
	(0.022)	(0.022)	(0.021)
Poor 10% - 20%	0.035	0.035^{*}	0.015
	(0.022)	(0.021)	(0.021)
Poor 20% - 30%	0.007	0.014	0.012
	(0.02)	(0.019)	(0.02)
Poor 30% - 40%	0.03	0.034	0.015
	(0.022)	(0.021)	(0.021)
Poor 40% - 50%	0.005	0.003	-0.004
	(0.02)	(0.019)	(0.018)
Experimental controls	-	Yes	Yes
Person controls	-	-	Yes
Constant	0.345^{***}	0.378^{***}	0.378^{***}
	(0.009)	(0.011)	(0.016)
N	1084	1084	1075
R^2	0.006	0.084	0.157

Notes: (1), (2), and (3) are OLS estimates of the coefficient of being in the respective lowest income group (=1 if subject is in the group) for relative counting errors (dependent variable). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

4.4.2.2 Payday effects on relative counting errors

Our analysis of the effect of payday on relative counting errors shows that the relative counting errors decrease after the payday, but this effect is not robust and significant (see Table 10). One reason why we do not find a significant payday effect could be that the primary task is too easy compared to the overall high living standard in Germany. If that explanation is true, the working memory load, which leads the poor to be less inattentional blind, is not sufficient to hamper performance in the primary task.
Our sample contains four groups: subjects counting the squares, the circles, the white, or the black shapes. Subjectively, counting the squares is the most difficult task. Table 9 confirms this: The relative errors between the four groups differ markedly, which suggests that the tasks differ in their level of difficulty. According to Table 9, counting the squares was the most difficult task. Therefore, in column (5) of Table 10, we restrict our sample to subjects counting how often the squares touch the frame of the video. The results show a significant negative effect of the payday. Consequently, less inattentional blindness comes at the expense of performance in the primary task only if the primary task is sufficiently difficult.

TABLE 9: Relative errors by primary task.

Variable	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs.**
Squares	0.43	0.187	0	0.765	258
White shapes	0.392	0.170	0	0.733	290
Black shapes	0.314	0.213	0	0.786	271
Circles	0.291	0.205	0	0.75	265

As in the section on inattentional blindness, one concern is that these differences in relative counting errors around the turn of the month are not the result of the financial situation, but of some other events that coincide with the turn of the month. Therefore, we also compare the relative counting errors of the respondents that we dropped because they are not employed. Table 11 shows the estimates for different post-payday periods for these respondents. Although, we expect that the estimated effect compared to Table 10 is not significantly different from zero, we actually find some significant positive effects (see Table 11), i.e., for this group of respondents relative counting errors increase after payday. In column (5), where we restrict the sample to subjects counting the squares, in contrast to the sample of employed subjects, the effects are not significantly different from zero if the post-payday range is sufficiently small.
The estimates of the difference-in-differences in Table 12 give a similar picture. We do not find clear evidence for a payday effect on relative counting error. Columns (1) to (3) include all subjects. Columns (4) to (6) restrict the sample to subjects who count the squares. Although we find that the relative counting error decreases for the group of employed individuals at least for a few days after the payday, the

TABLE 10: The effect of post-payday on relative counting errors.

	(1)	(2)	(3)	(4)	(5)
(a) 8 days post-payday	−0.009	−0.018	−0.004	−0.003	−0.051
	(0.025)	(0.027)	(0.026)	(0.025)	(0.049)
$N_{post-payday}$	80	80	80	80	17
R^2	0.000	0.028	0.101	0.173	0.229
(b) 7 days post-payday	0.011	0.007	0.018	0.012	−0.042
	(0.027)	(0.03)	(0.029)	(0.028)	(0.054)
$N_{post-payday}$	66	66	66	66	16
R^2	0.000	0.027	0.102	0.173	0.227
(c) 6 days post-payday	−0.002	−0.001	0.01	0.007	−0.073
	(0.029)	(0.034)	(0.033)	(0.03)	(0.056)
$N_{post-payday}$	53	53	53	53	13
R^2	0.000	0.027	0.101	0.173	0.232
(d) 5 days post-payday	−0.045	−0.06	−0.04	−0.037	-0.159^{***}
	(0.037)	(0.04)	(0.041)	(0.038)	(0.057)
$N_{post-payday}$	33	33	33	33	8
R^2	0.003	0.032	(0.103)	0.175	0.248
(e) 4 days post-payday	−0.027	−0.036	−0.018	−0.021	-0.137^{**}
	(0.043)	(0.049)	(0.05)	(0.047)	(0.056)
$N_{post-payday}$	26	26	26	26	6
R^2	0.001	0.028	0.101	0.173	0.241
(f) 3 days post-payday	−0.019	−0.022	−0.009	−0.015	-0.137^{**}
	(0.047)	(0.054)	(0.055)	(0.051)	(0.056)
$N_{post-payday}$	23	23	23	23	6
R^2	0.000	0.027	0.101	0.173	0.241
(g) 2 days post-payday	−0.032	−0.043	−0.029	−0.039	-0.106^{*}
	(0.054)	(0.065)	(0.062)	(0.057)	(0.06)
$N_{post-payday}$	17	17	17	17	5
R^2	0.001	0.028	0.102	0.174	0.231
(h) 1 day post-payday	−0.046	−0.054	−0.044	−0.045	-0.146^{**}
	(0.078)	(0.084)	(0.077)	(0.069)	(0.067)
$N_{post-payday}$	10	10	10	10	3
R^2	0.001	0.028	0.102	0.174	0.234
N	516	516	516	516	138
Dummies for weekday	-	Yes	Yes	Yes	Yes
Dummies for month	-	Yes	Yes	Yes	Yes
Experimental controls	-	-	Yes	Yes	-
Person controls	-	-	-	Yes	Yes

Notes: (1),(2),(3), (4), and (5) are OLS estimates of the coefficient of (a) 8, (b) 7, (c) 6, (d) 5, (e) 4, (f) 3, (g) 2, and (h) 1 days post-payday (=1 if subject is interviewed post-payday) on the relative counting errors (dependent variable). (5) is restricted to subjects who count squares. Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person characteristics include age (centered), gender, and education (casmin) dummies; Robust standard errors in parenthesis. $^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

TABLE 11: Placebo-Test of the effect of post-payday on relative counting errors.

	(1)	(2)	(3)	(4)	(5)
(a) 8 days post-payday	0.026	0.026	0.026	0.015	0.075
	(0.021)	(0.024)	(0.022)	(0.023)	(0.055)
$N_{post-payday}$	107	107	107	107	22
R^2	0.003	0.028	0.121	0.183	0.251
(b) 7 days post-payday	0.045^{**}	0.039	0.037	0.027	0.113^{**}
	(0.022)	(0.026)	(0.024)	(0.025)	(0.055)
$N_{post-payday}$	88	88	88	88	19
R^2	0.007	0.03	0.123	0.184	0.268
(c) 6 days post-payday	0.045^{**}	0.043	0.039	0.025	0.044
	(0.023)	(0.028)	(0.026)	(0.027)	(0.061)
$N_{post-payday}$	70	70	70	70	12
R^2	0.006	0.03	0.122	0.184	0.241
(d) 5 days post-payday	0.056^{**}	0.059^{*}	0.052^{*}	0.036	0.027
	(0.027)	(0.031)	(0.03)	(0.032)	(0.079)
$N_{post-payday}$	48	48	48	48	8
R^2	0.006	0.032	0.123	0.184	0.239
(e) 4 days post-payday	0.072^{**}	0.09^{***}	0.084^{**}	0.07^{**}	0.034
	(0.03)	(0.032)	(0.033)	(0.034)	(0.082)
$N_{post-payday}$	39	39	39	39	6
R^2	0.008	0.037	0.128	0.189	0.239
(f) 3 days post-payday	0.077^{**}	0.091^{**}	0.088^{**}	0.073^{*}	-0.017
	(0.032)	(0.036)	(0.036)	(0.038)	(0.085)
$N_{post-payday}$	32	32	32	32	5
R^2	0.008	0.036	0.128	0.188	0.238
(g) 2 days post-payday	0.066	0.095^{**}	0.093^{**}	0.066	0.006
	(0.04)	(0.045)	(0.043)	(0.045)	(0.1)
$N_{post-payday}$	22	22	22	22	4
R^2	0.004	0.033	0.125	0.186	0.238
(h) 1 day post-payday	0.099	0.128^{*}	0.125^{**}	0.113^{*}	0.08
	(0.063)	(0.068)	(0.063)	(0.065)	(0.1)
$N_{post-payday}$	9	9	9	9	3
R^2	0.004	0.032	0.124	0.187	0.241
N	546	546	546	537	117
Dummies for weekday	-	Yes	Yes	Yes	Yes
Dummies for month	-	Yes	Yes	Yes	Yes
Experimental controls	-	-	Yes	Yes	Yes
Person controls	-	-	-	Yes	Yes

Notes: (1),(2),(3), (4), and (5) are OLS estimates of the coefficient of (a) 8, (b) 7, (c) 6, (d) 5, (e) 4, (f) 3, (g) 2, and (h) 1 days post-payday (=1 if subject is interviewed post-payday) on the relative counting errors (dependent variable). (5) is restricted to subjects who count squares. Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person characteristics include age (centered), gender, and education (casmin) dummies; Robust standard errors in parenthesis. $^{*}p < 0.10, ^{**} p < 0.05, ^{***} p < 0.01$

difference is not significant (column (1)). Furthermore, in contrast to our prediction that there is no effect for the group of individuals who are not employed, the difference (column (2)) is partially significantly different from zero. In addition, the difference is positive, i.e., the relative counting errors in this group increases after the payday. Consequently, the estimates of the difference-in-differences with all subjects in column (3) are negative. However, this effect is not significant. If we restrict the sample to subjects who count squares, the relative counting error decreases in the 1 to 6 days after the payday for the individuals who are employed (column (4)) as well as for the individuals who are not employed (column (5)). But these differences are not significant. In addition, the estimates of the difference-in-differences (column (6)) show that the relative counting error does not fall more in the group of the employed. In general, however, the estimates are not significantly different from zero. Overall thus the difference-in-differences estimates in Table 12 as well as the results from Tables 10 and 11 show no robust payday effect on the relative counting error.

4.5 Discussion

The SOEP-IS has the major advantage that it is a *representative* sample of German households. Yet, as German households are typically not subject to absolute poverty, our focus on Germany may give rise to critique. However Mani, Mullainathan, Shafir, and Zhao (2013) explicitly argue that their theory of scarcity refers to subjective scarcity. In other words, people face scarcity when their wants do not align with their financial possibilities. Mani, Mullainathan, Shafir, and Zhao (2013) explicitly state that this makes their theory not only applicable for developing countries but also for developed countries. By focusing on German households, our results on inattentional blindness provide further evidence for the generality of the theory.
Unfortunately, the data set does not include precise data on the individuals' paydays. Nevertheless, to assume the payday to be the last bank working day of each month is reasonable as the payday is the last bank working day (i) for the salaries in the public sector for employees,[31] (ii) the salaries in the public sector for the military and civil servants,[32] and (iii) the salaries of apprentices.[33] This might be true for a majority of employees in other occupations as well. Yet, some will have different paydays. This would lead to an underestimation of the payday effect. However, there is no reason to belief that this would lead to a systematic bias.

[31] § 24 Abs 1 (TVöD, TV-L, TV-H).

[32] § 3 Abs 4 BBesG for civil servants of Germany and of the federal states of Saarland, Berlin, and Mecklenburg Western Pomerania; Art 4 Abs 3 BayBesG; § 3 Abs 4 (ThürBesG, LBesG NRW, LBesG LSA, BbgBesG); § 3 Abs 5 HBesG; § 4 Abs 4 (NBesG, BremBesG, HmbBesG, SHBesG); § 5 Abs 1 LBesGBW; § 6 Abs 1 SächsBesG; § 8 Abs 1 LBesG for civil servants of the respective federal states.

[33] § 18 Abs 2 BBiG.

TABLE 12: The effect of post-payday on relative counting errors: difference-in-differences analysis.

	All			Squares		
	(1) Employed	(2) Not employed	(3) Difference in differences	(4) Employed	(5) Not employed	(6) Difference in -differences
(a) 8 days post-payday						
Difference over time	0	0.015	−0.015	0.008	0.004	0.004
	(0.024)	(0.022)	(0.031)	(0.048)	(0.048)	(0.062)
(b) 7 days post-payday						
Difference over time	0.016	0.03	−0.014	0.03	0.04	−0.01
	(0.026)	(0.023)	(0.033)	(0.05)	(0.043)	(0.058)
(c) 6 days post-payday						
Difference over time	0.005	0.031	−0.026	−0.012	−0.018	0.005
	0.029	(0.025)	(0.036)	(0.05)	(0.044)	(0.059)
(d) 5 days post-payday						
Difference over time	−0.03	0.035	−0.065	−0.091*	−0.042	−0.049
	(0.036)	(0.029)	(0.044)	(0.052)	(0.051)	(0.063)
(e) 4 days post-payday						
Difference over time	−0.015	0.066**	−0.081	−0.091*	−0.042	−0.049
	(0.044)	(0.031)	(0.051)	(0.054)	(0.058)	(0.072)
(f) 3 days post-payday						
Difference over time	−0.011	0.073**	−0.084	−0.093	−0.075	−0.019
	(0.048)	(0.035)	(0.057)	(0.055)	(0.058)	(0.071)
(g) 2 days post-payday						
Difference over time	−0.027	0.056	−0.083	−0.05	−0.056	0.007
	(0.051)	(0.042)	(0.061)	(0.05)	(0.071)	(0.073)
(h) 1 day post-payday						
Difference over time	−0.032	0.092	−0.124	−0.064	−0.007	−0.057
	(0.066)	(0.059)	(0.085)	(0.059)	(0.073)	(0.075)
N	516	537		138	117	

Notes: The table reports the estimates of the differences over time in relative counting errors in the group of the employed and in the group of the not employed and the difference-in-differences estimates. The reported difference over time is the difference between the individuals interviewed (a) 8, (b) 7, (c) 6, (d) 5, (e) 4, (f) 3, (g) 2, or (h) 1 days post-payday and those individuals interviewed on some other day. Columns (1), (2), and (3) include all observations. Columns (4), (5), and (6) are restricted to the subjects who count how often the squares touch the frame of the video. Controls include dummies for weekday and month, experimental controls, i.e., whether the subject counts squares, circles, white, or black shapes (except for columns (4), (5), and (6)), and person controls, i.e., age (centered), gender, and education (casmin) dummies. Robust standard errors in parenthesis. $^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

The scarcity literature argues that poverty has a causal effect on cognitive functions and that other types of scarcity next to scarcity of financial resources (i.e., poverty) have similar effects. Therefore, a fruitful avenue for future research would be to analyze whether our results are generalizeable to other types of scarcity such as time scarcity.

4.6 Conclusion

Overall our results indicate that the poor and the rich differ systematically in their attention allocation. We find that the poor are more likely to notice unexpected events. In addition, we do not find robust evidence that this reduced inattentional blindness is at the expense of performance at the primary task. In particular, our results provide evidence for a causal link between poverty and inattentional blindness: Exploiting the exogenous variation in the timing of the experiment, we show that the circumstance of being poor influences attention. These results indicate that in line with earlier research (Shah, Mullainathan, and Shafir, 2012; Mani, Mullainathan, Shafir, and Zhao, 2013) the poor are more easily distracted. Consequently, the poor are less likely to focus exclusively on their task and are more likely to notice unexpected events. In some cases noticing unexpected events is beneficial. For example, noticing unexpected events is beneficial when drivers notice pedestrians or workers notice early signs of machine failure.

Understanding the differences in attention allocation is relevant to design better policies. Our results highlight the significance of timing policy interventions well. Inattentional blindness increases after payday. Thus making people aware of new policy programs might be more difficult after paydays. In contrast, difficult tasks like applying for assistance programs might be better timed post-payday, when concentration is comparatively higher.

4.7 Appendix

4.7.1 Descriptive statistics and balance test

Overall, 1370 individuals participated in the inattentional blindness experiment. Out of these 1370 individuals, we drop 286 individuals because they either do not report their count, do not answer the question whether they noticed an unexpected event, were among the 5% of respondents with the worst relative counting errors, or had missing income data. One concern is that our sample of 1084 respondents and the group of dropped individuals differ significantly and that there is selection into the sample. To address this concern, we analyze the differences between our sample and the 286 individuals in Table 13. Columns (1) and (2) report the mean with standard deviation in parenthesis of our sample and the 286 individuals that we dropped. Column (3) reports the absolute differences in the means between the two groups and column (4) reports the p-value from a t-test of equality of means. Table 13 shows that the two groups differ especially in the age of the respondents. In addition, column (5) shows the estimates of regressing all observables simultaneously on sample participation, i.e., dependent variable is 1 if the individual is part of our sample and the dependent variable is 0 if the individual was dropped. Column (5) shows that only age significantly predicts participation in the sample. In our analysis of the effects of poverty on inattentional blindness and on relative counting errors, we control for age (as well as gender and education).

For the payday analysis, we restrict our sample further to respondents who were not interviewed on a payday and who are employed. Table 14 reports the differences between respondents in our payday sample and the respondents that we dropped. Columns (1) and (2) report the mean with standard deviation in parenthesis of our payday sample and the 568 individuals that we dropped. Column (3) reports the absolute differences in the means between the two groups and column (4) reports the p-value from a t-test of equality of means. In addition, column (5) shows the estimates of a linear regression on sample participation, i.e., dependent variable is 1 if the individual is part of our sample and the dependent variable is 0 if the individual was dropped. Table 14 shows significant differences in age and education between the two groups. As we exclude all pensioners and all unemployed, these differences are expected. Nevertheless, in our payday analysis, we control for age, gender, and education.

Table 13: Balance test.

	(1) Sample	(2) Not in sample	(3) Absolute difference	(4) p-value	(5) Sample
Age	50.285	56.825	6.54	0.000	-0.003^{***}
	(17.719)	(18.883)			(0.001)
Female	0.518	0.51	−0.008	0.811	0.007
	(0.5)	(0.501)			(0.022)
German nationality	0.932	0.941	0.009	0.594	−0.017
	(0.252)	(0.237)			(0.047)
Unemployed	0.064	0.07	0.006	0.702	−0.026
	(0.244)	(0.255)			(0.047)
Higher tertiary education	0.123	0.105	−0.018	0.409	0.012
	(0.328)	(0.307)			(0.119)
Lower tertiary education	0.056	0.049	−0.007	0.629	0.019
	(0.231)	(0.216)			(0.124)
Vocational maturity certificate	0.101	0.063	−0.039	0.046	0.038
	(0.302)	(0.243)			(0.12)
General maturity certificate	0.067	0.042	−0.025	0.114	0.015
	(0.251)	(0.201)			(0.122)
Intermediate vocational	0.265	0.248	−0.017	0.572	−0.002
	(0.441)	(0.433)			(0.117)
Intermediate general qualification	0.047	0.056	0.009	0.535	−0.052
	(0.212)	(0.23)			(0.127)
Basic vocational qualification	0.241	0.304	0.063	0.028	−0.021
	(0.428)	(0.461)			(0.119)
General elementary school	0.067	0.091	0.024	0.171	−0.037
	(0.251)	(0.288)			(0.124)
Inadequately completed	0.02	0.031	0.011	0.259	−0.104
	(0.141)	(0.175)			(0.141)
In school	0.004	0.003	0.000	0.962	−0.101
	(0.061)	(0.059)			(0.214)
N	1084	286			1370

Notes: Columns (1) and (2) report the means of our sample and of the observations we dropped with standard deviation in parenthesis, column (3) reports the absolute difference, and column (4) reports the p-value from a t-test of equality of means. Column (5) shows the OLS estimates of the coefficients for participation in the sample (dependent variable=1 if the respondent is included in the sample) with robust standard errors in parenthesis. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Balance test.

	(1) Sample	(2) Not in sample	(3) Absolute difference	(4) p-value	(5) Sample
Age	42.57	57.294	14.724	0.000	-0.013^{***}
	(12.833)	(18.62)			(0.001)
Female	0.527	0.511	-0.017	0.586	0.02
	(0.5)	(0.5)			(0.027)
German nationality	0.926	0.937	0.01	0.504	-0.029
	(0.261)	(0.244)			(0.059)
Higher tertiary education	0.14	0.107	-0.032	0.107	0.606^{***}
	(0.347)	(0.31)			(0.115)
Lower tertiary education	0.07	0.044	-0.026	0.066	0.687^{***}
	(0.255)	(0.205)			(0.121)
Vocational maturity certificate	0.13	0.076	-0.054	0.003	0.601^{***}
	(0.336)	(0.265)			(0.118)
General maturity certificate	0.07	0.065	-0.005	0.762	0.41^{***}
	(0.255)	(0.247)			(0.123)
Intermediate vocational	0.312	0.222	-0.09	0.001	0.62^{***}
	(0.464)	(0.416)			(0.112)
Intermediate general qualification	0.025	0.067	0.042	0.001	0.295^{**}
	(0.157)	(0.25)			(0.123)
Basic vocational qualification	0.196	0.282	0.086	0.001	0.581^{***}
	(0.397)	(0.45)			(0.113)
General elementary school	0.045	0.088	0.043	0.004	0.455^{***}
	(0.207)	(0.284)			(0.12)
Inadequately completed	0.014	0.026	0.013	0.135	0.312^{**}
	(0.116)	(0.16)			(0.144)
In school	0	0.007	0.007	0.056	-0.321^{***}
	(0)	(0.084)			(0.112)
N	516	568			1084

Notes: Columns (1) and (2) report the means of our payday sample and of the observations we dropped with standard deviation in parenthesis, column (3) reports the absolute difference, and column (4) reports the p-value from a t-test of equality of means. Column (5) shows the OLS estimates of the coefficients for participation in the sample (dependent variable=1 if the respondent is included in the sample) with robust standard errors in parenthesis. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.7.2 Robustness checks

As a robustness check, we use two further measures of poverty. First, we define an individual as poor if the effective household income lies below a threshold of 60% of the median of the effective household income. Second, we use a threshold of 50% of the median of the effective household income.

4.7.2.1 Poverty and inattentional blindness

Tables 15 and 16 show the estimates of the effect of poverty on inattentional blindness. In line with our previous findings, poverty decreases inattentional blindness. However, as the the definition becomes more restrictive, less people are defined as poor which reduces the precision of the estimates.

TABLE 15: The effect of poverty (defined as effective household income below 60% of the median effective household income) on inattentional blindness.

	(1)	(2)	(3)	(4)
Poverty	-0.043	-0.047	-0.068^{*}	-0.364^{*}
	(0.038)	(0.038)	(0.04)	(0.204)
Experimental controls	-	Yes	Yes	Yes
Person controls	-	-	Yes	Yes
Constant	0.753^{***}	0.802^{***}	0.792^{***}	1.358^{***}
	(0.014)	(0.025)	(0.038)	(0.22)
N	1084	1084	1075	1075
R^2	0.001	0.013	0.037	0.033

Notes: (1), (2), and (3) are OLS estimates, (4) reports the estimates of a logit regression (the reported R^2 here is the corresponding Pseudo R^2) of poverty (=1 if the subject's effective household income is below 60% of the median effective household income) on inattentional blindness (dependent variable=1 if subject is inattentional blind). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

TABLE 16: The effect of poverty (defined as effective household income below 50% of the median effective household income) on inattentional blindness.

	(1)	(2)	(3)	(4)
Poverty	-0.087^{*}	-0.09^{*}	-0.097^{*}	-0.507^{**}
	(0.051)	(0.051)	(0.053)	(0.253)
Experimental controls	-	Yes	Yes	Yes
Person controls	-	-	Yes	Yes
Constant	0.754^{***}	0.804^{***}	0.79^{***}	1.353^{***}
	(0.014)	(0.024)	(0.038)	(0.22)
N	1084	1084	1075	1075
R^2	0.003	0.015	0.038	0.034

Notes: (1), (2), and (3) are OLS estimates, (4) reports the estimates of a logit regression (the reported R^2 here is the corresponding Pseudo R^2) of poverty (=1 if the subject's effective household income is below 50% of the median effective household income) on inattentional blindness (dependent variable=1 if subject is inattentional blind). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.7.2.2 Logarithmic effective household income and inattentional blindness

The estimates of Table 17 confirm the findings of Section 4.4.1.1. The probability of being inattentional blind increases with the logarithmic effective household income. Figure 10 shows the probabilities of inattentional blindness for different levels of the logarithmic effective household income. The probability of inattentional blindness for a respondent of mean age with a logarithmic effective household income of 6 ($\approx$ 400 Euro) is 63.99%, whereas the probability of inattentional blindness for an respondent of mean age with a logarithmic effective household income of 9 ($\approx$ 8100 Euro) is 84.78%.

4.7.2.3 Poverty and relative counting errors

Tables 18 and 19 show the estimates of the effect of poverty on relative counting errors. The more restrictive definitions of poverty yield higher relative counting errors compared to the median split. Overall, these results are in line with our earlier analysis.

Table 17: The effect of logarithmic effective household income on inattentional blindness.

	(1)	(2)	(3)	(4)
Log effective household income	0.045*	0.049*	0.073**	0.391**
	(0.027)	(0.027)	(0.03)	(0.16)
Experimental controls	-	Yes	Yes	Yes
Person controls	-	-	Yes	Yes
Constant	0.412**	0.436**	0.246	−1.568
	(0.201)	(0.201)	(0.223)	(1.179)
N	1084	1084	1075	1075
R^2	0.003	0.015	0.04	0.036

Notes: (1), (2), and (3) are OLS estimates, (4) are estimates from a logit regression (the reported R^2 here is the corresponding Pseudo R^2) with changes in the logarithmic chance of inattentional blindness (dependent variable=1 if subject is inattentional blind). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

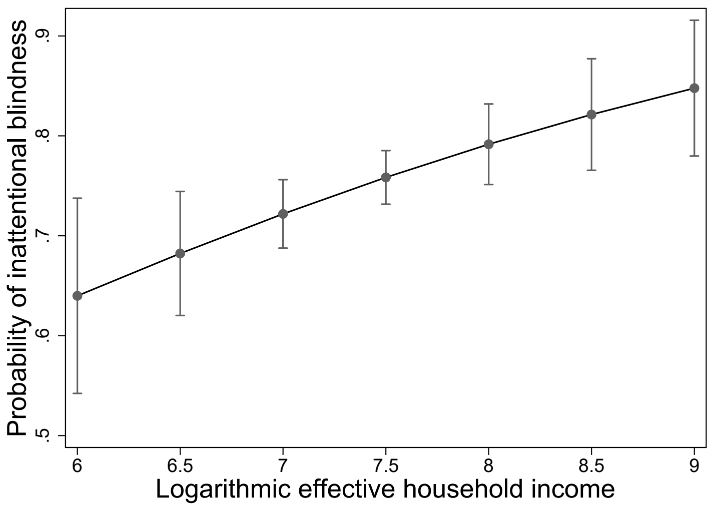

Figure 10: Predictive margins with 95% confidence intervals.

Table 18: The effect of poverty (defined as effective household income below 60% of the median effective household income) on relative counting errors.

	(1)	(2)	(3)
Poverty	0.039**	0.04**	0.037**
	(0.018)	(0.017)	(0.017)
Experimental controls	-	Yes	Yes
Person controls	-	-	Yes
Constant	0.351***	0.384***	0.379***
	(0.007)	(0.01)	(0.015)
N	1084	1084	1075
R^2	0.005	0.082	0.158

Notes: (1), (2), and (3) are OLS estimates with the coefficient of poverty (=1 if the subject's effective household income is below 60% of the median effective household income) for relative counting errors (dependent variable). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 19: The effect of poverty (defined as effective household income below 50% of the median effective household income) on relative counting errors.

	(1)	(2)	(3)
Poverty	0.036	0.035	0.042*
	(0.024)	(0.023)	(0.022)
Experimental controls	-	Yes	Yes
Person controls	-	-	Yes
Constant	0.354***	0.388***	0.381***
	(0.006)	(0.01)	(0.015)
N	1084	1084	1075
R^2	0.002	0.079	0.157

Notes: (1), (2), and (3) are OLS estimates with the coefficient of poverty (=1 if the subject's effective household income is below 50% of the median effective household income) for relative counting errors (dependent variable). Experimental controls include whether the subject counts squares, circles, white, or black shapes. Person controls include age (centered), gender, and education (casmin) dummies. Robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.7.2.4 Symmetric payday-ranges and inattentional blindness

In Table 20, we analyze the effect of the payday in a symmetric setting; that is, whether the respondent is interviewed within a range of days before or after the payday. The coefficients do show an increased probability of inattentional blindness for those interviewed after the payday. But because of the reduced number of cases within those short periods around payday, those results mainly fail to be statistically significant.

Table 21 provides a placebo-test, i.e., whether the non-employed also differ in inattentional blindness around the "payday." In contrast to Table 20, the effect is often negative and only one estimate is significant.

Table 20: The effect of pre- vs. post-payday on inattentional blindness.

	(1)	(2)	(3)	(4)	(5)
(a) 8 days post-payday	0.036	0.051	0.044	0.033	0.15
	(0.059)	(0.071)	(0.07)	(0.072)	(0.414)
N pre-/post-payday	153/80	153/80	153/80	153/80	152/80
R^2	0.002	0.03	0.073	0.105	0.093
(b) 7 days post-payday	0.067	0.089	0.079	0.054	0.313
	(0.063)	(0.074)	(0.074)	(0.076)	(0.444)
N pre-/post-payday	129/66	129/66	129/66	129/66	128/66
R^2	0.005	0.046	0.084	0.146	(0.131)
(c) 6 days post-payday	0.113*	0.147**	0.125*	0.105	0.777
	(0.062)	(0.073)	(0.075)	(0.081)	(0.566)
N pre-/post-payday	110/53	110/53	110/53	110/53	86/36
R^2	0.017	0.049	0.128	0.203	0.137
(d) 5 days post-payday	0.148**	0.221**	0.185*	0.177*	1.455
	(0.067)	(0.086)	(0.094)	(0.101)	(1.129)
N pre-/post-payday	92/33	92/33	92/33	92/33	73/19
R^2	0.027	0.105	(0.156)	0.269	0.231
(e) 4 days post-payday	0.126	0.171*	0.134	0.161	1.115
	(0.079)	(0.098)	(0.105)	(0.118)	(1.204)
N pre-/post-payday	83/26	83/26	83/26	83/26	66/17
R^2	0.017	0.114	0.162	0.27	0.228
(f) 3 days post-payday	0.132	0.204	0.159	0.202	1.356
	(0.091)	(0.171)	(0.173)	(0.205)	(1.798)
N pre-/post-payday	61/23	61/23	61/23	61/23	47/13
R^2	0.02	0.094	0.136	0.264	0.139
(g) 2 days post-payday	0.085	−0.031	−0.118	−0.262	-
	(0.117)	(0.217)	(0.229)	(0.247)	-
N pre-/post-payday	42/17	42/17	42/17	42/17	-
R^2	0.008	0.145	0.202	0.456	-
(h) 1 day post-payday	0.025	0.067	0.335	−0.324	-
	(0.12)	(0.198)	(0.263)	(0.269)	-
N pre-/post-payday	24/10	24/10	24/10	24/10	-
R^2	0.001	0.018	0.174	0.575	-
Dummies for weekday	-	Yes	Yes	Yes	Yes
Dummies for month	-	Yes	Yes	Yes	Yes
Experimental controls	-	-	Yes	Yes	Yes
Person controls	-	-	-	Yes	Yes

Notes: (1),(2),(3), and (4) are OLS estimates, (5) are estimates from a logit regression (the R^2 is the Pseudo R^2) with coefficient for post-payday (=1 if subject is interviewed post-payday; =0 if subject is interviewed pre-payday) on inattentional blindness (dependent variable=1 if subject is inattentional blind). Experimental controls include whether subjects count squares, circles, white, or black shapes. Person characteristics include age (centered), gender, and education (casmin) dummies. Robust standard errors in parenthesis. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 21: Placebo-Test of the effect of pre- vs. post-payday on inattentional blindness.

	(1)	(2)	(3)	(4)	(5)
(a) 8 days post-payday	0.02	−0.052	−0.049	−0.061	−0.417
	(0.052)	(0.068)	(0.068)	(0.072)	(0.513)
N pre-/post-payday	135/107	135/107	135/107	133/107	128/99
R^2	0.001	0.069	0.081	0.157	0.157
(b) 7 days post-payday	0.03	0.008	0.006	−0.02	−0.088
	(0.058)	(0.074)	(0.075)	(0.079)	(0.524)
N pre-/post-payday	112/88	112/88	112/88	111/88	106/83
R^2	0.001	0.066	0.075	0.163	(0.146)
(c) 6 days post-payday	0.025	−0.01	−0.016	−0.048	−0.515
	(0.066)	(0.084)	(0.084)	(0.089)	(0.691)
N pre-/post-payday	89/70	89/70	89/70	88/70	79/61
R^2	0.001	0.087	0.105	0.255	0.251
(d) 5 days post-payday	0.106	0.055	0.056	−0.013	−0.406
	(0.077)	(0.101)	(0.102)	(0.11)	(1.309)
N pre-/post-payday	66/48	66/48	66/48	66/48	59/42
R^2	0.016	0.101	(0.118)	0.338	0.376
(e) 4 days post-payday	0.086	0.047	0.039	0.015	−0.21
	(0.083)	(0.113)	(0.116)	(0.123)	(1.161)
N pre-/post-payday	64/39	64/39	64/39	64/39	57/36
R^2	0.01	0.078	0.108	0.335	0.36
(f) 3 days post-payday	0.07	0.143	0.137	0.03	0.873
	(0.101)	(0.169)	(0.179)	(0.201)	(1.552)
N pre-/post-payday	45/32	45/32	45/32	45/32	40/30
R^2	0.006	0.101	0.114	0.366	0.436
(g) 2 days post-payday	0.051	0.164	0.123	0.131	-
	(0.118)	(0.208)	(0.222)	(0.249)	-
N pre-/post-payday	36/22	36/22	36/22	36/22	-
R^2	0.003	0.142	0.231	0.411	-
(h) 1 day post-payday	0.246*	-	-	−0.071	-
	(0.142)	-	-	(0.432)	-
N pre-/post-payday	28/9	-	-	28/9	-
R^2	0.053	-	-	0.588	-
Dummies for weekday	-	Yes	Yes	Yes	Yes
Dummies for month	-	Yes	Yes	Yes	Yes
Experimental controls	-	-	Yes	Yes	Yes
Person controls	-	-	-	Yes	Yes

Notes: (1),(2),(3), and (4) are OLS estimates, (5) are estimates from a logit regression (the R^2 is the Pseudo R^2) with coefficent for post-payday (=1 if subject is interviewed post-payday; =0 if subject is interviewed pre-payday) on inattentional blindness (dependent variable=1 if subject is inattentional blind). Experimental controls include whether subjects count squares, circles, white, or black shapes. Person characteristics include age (centered), gender, and education (casmin) dummies. Robust standard errors in parenthesis. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

References

Abeler, J., and S. Jäger (2015): "Complex Tax Incentives," *American Economic Journal: Economic Policy*, 7(3), 1–28.

Armstrong, M. (2006a): "Competition in two-sided markets," *RAND Journal of Economics*, 37(3), 668–691.

——— (2006b): "Recent developments in the economics of price discrimination," in *Advances in Economics and Econometrics: Theory and Applications, Ninth World Congress of the Econometric Society*, ed. by R. Blundell, W. K. Newey, and T. Persson, vol. 2, pp. 97–141. Cambridge University Press, Cambridge.

Armstrong, M., and J. Vickers (2019): "Discriminating against Captive Customers," *AER: Insights*, 1(3), 257–272.

——— (2020): "Patterns of Competitive Interaction," *Working Paper.*

Astorne-Figari, C., J. J. López, and A. Yankelevich (2019): "Advertising for consideration," *Journal of Economic Behavior and Organization*, 157, 653–669.

Baker, W., M. Marn, and C. Zawada (2001): "Price Smarter on the Net," *Harvard Business Review*, 79(2), 122–127.

Bakos, J. Y. (1991): "A Strategic Analysis of Electronic Marketplaces," *Management Information Systems Quarterly*, 15(3), 295–310.

——— (1997): "Reducing buyer search costs: Implications for electronic marketplaces," *Management Science*, 43(12), 1676–1692.

Bartoš, V., M. Bauer, J. Chytilová, and I. Levely (2018): "Effects of Poverty on Impatience: Preferences or Inattention?," *CERGE-EI Working Paper Series*, 623.

Bester, H., and E. Petrakis (1995): "Price competition and advertising in oligopoly," *European Economic Review*, 39(6), 1075–1088.

Bohlender, A., and A. Glemser (2016): "SOEP-IS 2014 – Methodenbericht zum Befragungsjahr 2014 des SOEP-Innovationssamples," *SOEP Survey Papers 339: Series B - Survey Reports (Methodenberichte). Berlin: DIW/SOEP.*

Boone, J., and J. Pottersz (2006): "Transparency and prices with imperfect substitutes," *Economics Letters*, 93(3), 398—-404.

Bordalo, P., N. Gennaioli, and A. Shleifer (2013): "Salience and Consumer Choice," *Journal of Political Economics*, 121(5), 803–843.

——— (2016): "Competition for Attention," *Review of Economic Studies*, 83(5), 481–513.

Brown, J., T. Hossain, and J. Morgan (2010): "Shrouded Attributes and Information Suppression: Evidence from the Field," *Quarterly Journal of Economics*, 125, 859–876.

Brown, J. R., and A. Goolsbee (2002): "Does the Internet Make Markets More Competitive? Evidence from the Life Insurance Industry," *Journal of Political Economy*, 110(3), 481–507.

Busse, M. R., N. Lacetera, D. G. Pope, J. Silva-Risso, and J. R. Sydnor (2013): "Estimating the Effect of Salience in Wholesale and Retail Car Markets," *American Economic Review*, 103(3), 575–579.

Butters, G. R. (1977): "Equilibrium Distribution of Sales and Advertising Prices," *Review of Economic Studies*, 44(3), 465–491.

Cartwright-Finch, U., and N. Lavie (2007): "The role of perceptual load in inattentional blindness," *Cognition*, 102, 321–340.

Carvalho, L. S., S. Meier, and S. W. Wang (2016): "Poverty and Economic Decision-Making: Evidence from Changes in Financial Resources at Payday," *American Economic Review*, 106, 260–284.

Chabris, C. F., A. Weinberger, M. Fontaine, and D. J. Simons (2011): "You do not talk about Fight Club if you do not notice Fight Club: Inattentional blindness for a simulated real-world assault," *i-Perception*, 2, 150–153.

Chetty, R., A. Looney, and K. Kroft (2009): "Salience and Taxation: Theory and Evidence," *American Economic Review*, 99, 1145–1177.

Choe, C., S. King, and N. Matsushima (2018): "Pricing with Cookies: Behavior-Based Price Discrimination and Spatial Competition," *Management Science*, 64(12), 5669–5687.

Cosandier, C., F. Garcia, and M. Knauff (2018): "Price competition with differentiated goods and incomplete product awareness," *Economic Theory*, 66(3), 681–705.

Cremer, H., and J.-F. Thisse (1994): "Commodity Taxation in a Differentiated Oligopoly," *International Economic Review*, 35(3), 613–633.

Dalton, P. S., N. Nhung, and J. Rüschenpöhler (2020): "Worries of the poor: The impact of financial burden on the risk attitudes of micro-entrepreneurs," *Journal of Economic Psychology*, 79, Article 102198.

Dang, J., S. Xiao, T. Zhang, Y. Liu, B. Jiang, and L. Mao (2016): "When the poor excel: Poverty facilitates procedural learning," *Scandinavian Journal of Psychology*, 57, 288–291.

d'Aspremont, C., J. J. Gabszewicz, and J.-F. Thisse (1979): "On Hotelling's "Stability in Competition"," *Econometrica*, 47(5), 1145–1150.

de Fockert, J. W., and A. J. Bremner (2011): "Release of inattentional blindness by high working memory load: Elucidating the relationship between working memory and selective attention," *Cognition*, 121, 400–408.

Dean, E. B., F. Schilbach, and H. Schofield (2019): "Poverty and Cognitive Function," in *The Economics of Poverty Traps*, ed. by C. B. Barrett, M. R. Carter, and J.-P. Chavas, pp. 57–118. The University of Chicago Press.

Drew, T., and C. Stothart (2016): "Clarifying the role of target similarity, task relevance and feature-based suppression during sustained inattentional blindness," *Journal of Vision*, 16(15), 1–9.

Drew, T., M. L.-H. Võ, and J. M. Wolfe (2013): "The Invisible Gorilla Strikes Again: Sustained Inattentional Blindness in Expert Observers," *Psychological Science*, 24, 1848–1853.

Eliaz, K., and R. Spiegler (2011a): "Consideration Sets and Competitive Marketing," *Review of Economic Studies*, 78(1), 235–262.

——— (2011b): "On the strategic use of attention grabbers," *Theoretical Economics*, 6(1), 127–155.

Englmaier, F., A. Schmöller, and T. Stowasser (2018): "Price Discontinuities in an Online Market for Used Cars," *Management Science*, 64, 2754–2766.

Fehr, D., G. Fink, and K. Jack (2019): "Poverty, Seasonal Scarcity and Exchange Asymmetries," *NBER working paper No 26357*.

Feng, H., and J. Ma (2018): "Location choices and third-degree spatial price discrimination," *Scottish Journal of Political Economy*, 65(2), 142–153.

Fudenberg, D., and J. Tirole (2000): "Customer poaching and brand switching," *RAND Journal of Economics*, 31(4), 634–657.

Gabaix, X. (2019): "Behavioral inattention," in *Handbook of Behavioral Economics: Foundations and Applications*, ed. by B. D. Bernheim, S. DellaVigna, and D. Laibson, vol. 2, pp. 261–343. Elsevier Science & Technology, Amsterdam.

Gabszewicz, J., and J.-F. Thisse (1979): "Price competition, quality and income disparities," *Journal of Economic Theory*, 20(3), 340–359.

Gabszewicz, J. J., and X. Y. Wauthy (2014): "Vertical product differentiation and two-sided markets," *Economic Letters*, 123, 58–61.

Goebel, J., S. Liebig, D. Richter, C. Schröder, J. Schupp, and K. Wenzig (2020): "SOEP-Innovationssample (SOEP-IS), Daten der Jahre 1998—2018," *DOI: 10.5684/ soep.is.2018*.

Goeree, M. S. (2008): "Limited Information and Advertising in the U.S. Personal Computer Industry," *Econometrica*, 76(5), 1017–1074.

Goldin, J., and T. Homonoff (2013): "Smoke Gets in Your Eyes: Cigarette Tax Salience and Regressivity," *American Economic Journal: Economic Policy*, 5(1), 302–336.

Graham, E. R., and D. M. Burke (2011): "Aging Increases Inattentional Blindness to the Gorilla in our Midst," *Psychology and Aging*, 26, 162–166.

Grossman, G. M., and C. Shapiro (1984): "Informative Advertising with Differentiated Products," *Review of Economic Studies*, 51(1), 63–81.

Hanna, R., S. Mullainathan, and J. Schwartzstein (2014): "Learning Through Noticing: Theory and Evidence from a Field Experiment," *Quarterly Journal of Economics*, 129, 1311–1353.

Hannak, A., G. Soeller, D. Lazer, A. Mislove, and C. Wilson (2014): "Measuring Price Discrimination and Steering on E-commerce Web Sites," in *IMC '14: Proceedings of the 2014 Conference on Internet Measurement Conference*, pp. 305–318, New York. ACM.

Hefti, A. (2018): "Limited attention, competition and welfare," *Journal of Economic Theory*, 178, 318–359.

Heidhues, P., and B. Köszegi (2017): "Naïveté-Based Discrimination," *Quarterly Journal of Economics*, 132(2), 1019–1054.

Hillenbrand, A., and S. Hippel (2019): "Strategic Inattention in Product Search," *MPI Collective Goods Preprint*, No. 2017/21.

Honka, E., A. Hortaçsu, and M. A. Vitorino (2017): "Advertising, consumer awareness, and choice: evidence from the U.S. banking industry," *RAND Journal of Economics*, 48(3), 611–646.

Horwood, S., and V. Beanland (2016): "Inattentional blindness in older adults: Effects of attentional set and to-be-ignored distractors," *Attention, Perception, & Psychophysics*, 78, 818–828.

Hotelling, H. (1929): "Stability in Competition," *Economic Journal*, 39(153), 41–57.

Hyman Jr., I. E., S. M. Boss, B. M. Wise, K. E. McKenzie, and J. M. Caggiano (2010): "Did You See the Unicycling Clown? Inattentional Blindness while Walking and Talking on a Cell Phone," *Applied Cognitive Psychology*, 24, 597–607.

Kahneman, D., and A. Tversky (1979): "Prospect Theory: An Analysis of Decision under Risk," *Econometrica*, 47(2), 263–291.

Kaur, S., S. Mullainathan, S. Oh, and F. Schilbach (2019): "Does Financial Strain Lower Productivity?," *working paper*.

Köszegi, B., and A. Szeidl (2013): "A Model of Focusing in Economic Choice," *Quarterly Journal of Economics*, 128(1), 53–104.

Lacetera, N., D. G. Pope, and J. R. Sydnor (2012): "Heuristic Thinking and Limited Attention in the Car Market," *American Economic Review*, 102, 2206–2236.

Lavie, N. (1995): "Perceptual Load as a Necessary Condition for Selective Attention," *Journal of Experimental Psychology: Human Perception and Performance*, 21, 451–468.

Lavie, N., A. Hirst, J. W. de Fockert, and E. Viding (2004): "Load Theory of Selective Attention and Cognitive Control," *Journal of Experimental Psychology: General*, 133, 339–354.

Lavie, N., and Y. Tsal (1994): "Perceptual load as a major determinant of the locus of selection in visual attention," *Attention, Perception, & Psychophysics*, 56, 183–197.

Lichand, G., and A. Mani (2020): "Cognitive Droughts," *University of Zurich, Department of Economics, Working Paper No. 341*.

Liu, Q., and K. Serfes (2004): "Quality of Information and Oligopolistic Price Discrimination," *Journal of Economics & Management Strategy*, 13(4), 671–702.

MACK, A. (2003): "Inattentional Blindness: Looking Without Seeing," *Current Directions in Psychological Science*, 12, 180–184.

MANI, A., S. MULLAINATHAN, E. SHAFIR, AND J. ZHAO (2013): "Poverty Impedes Cognitve Function," *Science*, 341, 976–980.

——— (2020): "Scarcity and Cognitive Function around Payday: A Conceptual and Empirical Analysis," *Journal of the Association for Consumer Research*, 5, 365–376.

MANZINI, P., AND M. MARIOTTI (2018): "Competing for Attention: Is the Showiest Also the Best?," *Economic Journal*, 128(609), 827–844.

MAURING, E. (2020): "Sequential Search with Limited Price Discrimination," *Working Paper*.

MEURER, M., AND D. O. STAHL II (1994): "Informative advertising and product match," *International Journal of Industrial Organization*, 12(1), 1–19.

MIKIANS, J., L. GYARMATI, V. ERRAMILLI, AND N. LAOUTARIS (2013): "Crowd-assisted Search for Price Discrimination in E-Commerce: First Results," in *Proceedings of the Ninth ACM Conference on Emerging Networking Experiments and Technologies*, pp. 1–6, New York. ACM.

MOST, S. B., D. J. SIMONS, B. J. SCHOLL, R. JIMENEZ, E. CLIFFORD, AND C. F. CHABRIS (2001): "How not to be Seen: The Contribution of Similarity and Selective Ignoring to Sustained Inattentional Blindness," *Psychological Science*, 12(1), 9–17.

MURPHY, G., AND C. M. GREENE (2016): "Perceptual Load Induces Inattentional Blindness in Drivers," *Applied Cognitive Psychology*, 30, 479–483.

MURPHY, G., J. A. GROEGER, AND C. M. GREENE (2016): "Twenty years of load theory—Where are we now, and where should we go next?," *Psychonomic Bulletin & Review*, 23, 1316–1340.

MUSSA, M., AND S. ROSEN (1978): "Monopoly and Product Quality," *Journal of Economic Theory*, 18, 301–317.

POLO, M. (1991): "Hotelling Duopoly with Uninformed Consumers," *Journal of Industrial Economics*, 39(6), 701–715.

PU, X., S. SUN, AND J. SHAO (2020): "Direct Selling, Reselling, or Agency Selling? Manufacturer's Online Distribution Strategies and Their Impact," *International Journal of Electronic Commerce*, 24(2), 232–254.

Richter, D., and J. Schupp (2015): "The SOEP Innovation Sample (SOEP IS)," *Schmollers Jahrbuch*, 135, 389–399.

Rochet, J.-C., and J. Tirole (2003): "Platform competition in two-sided markets," *Journal of the European Economic Association*, 1(4), 990–1029.

Roy, S. (2000): "Strategic segmentation of a market," *International Journal of Industrial Organization*, 18(8), 1279–1290.

Ryan, J. K., D. Sun, and X. Zhao (2012): "Competition and Coordination in Online Marketplaces," *Product and Operations Management*, 21(6), 997–1014.

Salop, S., and J. Stiglitz (1977): "Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion," *Review of Economic Studies*, 44(3), 493–510.

Schultz, C. (2004): "Market transparency and product differentiation," *Economics Letters*, 83(2), 173–178.

Shah, A. K., S. Mullainathan, and E. Shafir (2012): "Some Consequences of Having Too Little," *Science*, 338, 682–685.

——— (2019): "An exercise in self-replication: Replicating Shah, Mullainathan, and Shafir (2012)," *Journal of Economic Psychology*, 75(A), Article 102127.

Shah, A. K., E. Shafir, and S. Mullainathan (2015): "Scarcity Frames Value," *Psychological Science*, 26, 402–412.

Shah, A. K., J. Zhao, S. Mullainathan, and E. Shafir (2018): "Money in the Mental Lives of the Poor," *Social Cognition*, 36, 4–19.

Simons, D. J., and C. F. Chabris (1999): "Gorillas in our midst: sustained inattentional blindness for dynamic events," *Perception*, 28(9), 1059–1074.

Soberman, D. A. (2004): "Research Note: Additional Learning and Implications on the Role of Informative Advertising," *Management Science*, 50(12), 1744–1750.

SOEP-IS Group (2018): "SOEP-IS 2014 — Fragebogen für die SOEP-Innovatoins-Stichprobe (Update soep.is.2016.1)," *SOEP Survey Papers 519: Series A - Survey Instruments (Erhebungsinstrumente). Berlin: DIW/SOEP.*

Spears, D. (2011): "Economic Decision-Making in Poverty Depletes Behavioral Control," *The B.E. Journal of Economic Analysis & Policy*, 11(1), Article 72.

Stahl II, D. O. (1989): "Oligopolistic Pricing with Sequential Consumer Search," *American Economic Review*, 79(4), 700–712.

Stango, V., and J. Zinman (2014): "Limited and Varying Consumer Attention: Evidence from Shocks to the Salience of Bank Overdraft Fees," *Review of Financial Studies*, 27, 990–1030.

Stothart, C. R., W. R. Boot, and D. J. Simons (2015): "Using Mechanical Turk to Assess the Effects of Age and Spatial Proximity on Inattentional Blindness," *Collabra*, 1, 1–7.

Taylor, S., and S. Thompson (1982): "Stalking the Elusive Vividness Effect," *Psychological Review*, 89(2), 155–181.

Tian, L., A. J. Vakharia, Y. R. Tan, and Y. Xu (2018): "Marketplace, Reseller, or Hybrid: Strategic Analysis of an Emerging E-Commerce Model," *Production and Operations Management*, 27(8), 1595–1610.

Varian, H. R. (1980): "A Model of Sales," *American Economic Review*, 70(4), 651–659.

Wallheimer, B. (2018): "Are you ready for personalized pricing?," *Chicago Booth Review*, Spring.

Zang, J., Q. Cao, and X. He (2019): "Contract and product quality in platform selling," *European Journal of Operational Research*, 272(3), 928–944.

Zhao, J., and B. M. Tomm (2017): "Attentional Trade-Offs Under Resource Scarcity," in *Augmented Cognition*, ed. by D. D. Schmorrow, and C. M. Fidopiastis, pp. 78–97. Springer, Berlin.