

The influence of auditory stimuli on financial information processing

Abstract

Before signing a banking contract, an investor reads the Payment Account Fee Information Document (FID) which details the basic features and costs of a specific bank product. This usually happens in a bank branch, where customers are normally exposed to the buzz produced by other people talking or to a soft background music. The aim of this study is to describe the influence of auditory stimuli on attention allocation towards financial information, measured by the eye-tracking, and on emotional states, as inferred by the galvanic skin response (GSR). The analysis on a sample of 34 individuals revealed that their attention distribution was strongly influenced by the presence of music or buzz, compared with the silent condition and that auditory stimuli are associated to higher fixation time, for each AOIs. When the couple of documents is presented, subjects tend to compare section by section with a left-to-right path, and *Liquidity* is the section associated to higher attention, followed by the sections *fixed* and *variable* costs. This study shows the importance of the environmental conditions that bank should consider and manage to enhance investors' information processing before signing a contract, since buzz, but also ambient music, are likely to interfere with the individual financial decision making.

1. Introduction

Among the different environmental stimuli which can affect consumers' behaviour, three factors have been found to be particularly relevant: colour, smell and music. The influence of these environmental conditions on behaviour has been studied for different contexts as waiting rooms, restaurants or retail shops, in different settings, as laboratories or real shops, and with respect to different shopping outcomes as time spent in the store, amount of money spent, satisfaction, and pleasure (Yalch and Spangenberg 2000; for a review, see Turley and Milliman 2000). Even if consumers are often unaware to be exposed to environmental factors, these affect their behaviour and thus retailers use subtle atmospheric stimuli to intentionally enhance consumers' impulse to buy. Since the influence of the environmental conditions on decision making occurs below subjects' awareness, the mere study of subjective experience through self-report measures does not capture the automatic and unconscious mechanisms which affect decisions. But acknowledging the importance to understand the neurophysiological substrate of decisions, academics in neuromarketing and practitioners are recently applying neuroscientific techniques, to "open" consumers' black box. Conversely, researchers in finance are largely reluctant in merging traditional theoretical views with methods and investigation techniques used in neuroscience and psychology, to understand and describe the *neural mechanisms* which underlie financial agent's decisions making. Recently, some scholars have investigated how investors' behaviour is unconsciously affected by different factors which have been largely disregarded by traditional financial theory (Raggetti et al. 2017). For instance, Ceravolo et al. (2019a),

analysing individuals' oculomotor behaviour by means of eye tracking, have reported that the way financial information is presented to investors in the *Key Investor Information Document* influences their attentional mechanisms. A specific financial document layout is associated to higher processing time and to a lower financial attractiveness perception. In another study that exploits the same investigation technique, Ceravolo et al. (2019b) highlight that also another factor whose influence on financial behaviour has been poorly explored - the colour - affects both subjects' attentional mechanisms while processing financial information and their final judgments about products' attractiveness. Surprisingly, only colour has been investigated in neurofinance as a factor that modulate investors' behaviour, while the role of smell and music has not received the deserved attention. In this study, we aim at filling this gap in the financial literature, by unveiling for the first time the influence of background music on financial agents' behaviour. Financial decision making process consists of several phases, which could be summarized (simplifying) in: stimuli perception, collection, selection, elaboration, interpretation, classification, memorization, integration, evaluation, action and outcome evaluation. The initial phases of visual stimuli perception, collection and selection are very relevant since they modulate all the subsequent ones; they occur through visual attention, a selective function which allows the brain to drop out irrelevant cues while gathering relevant ones, in few milliseconds. Since subjects do not have any introspective access on this automatic function, measuring individuals' gaze, detecting where and how long they process a visual stimulus, permits to infer what is grabbing brain's interest. This sheds light on individuals' information processing, which has a major role on the final decision outcome. In this research, we focus on attentional mechanisms: a crucial phenomenon in any initial phase of decision-making process, including the financial one. The opening of a bank account offers an interesting and simple scenario to study the neurophysiological bases of investors' behaviour. The strict transparency regulation in banking, aims to protect the clients: before they sign any contract, the bank must present a mandatory disclosure document known as the Payment Account Fees Information Document (hence after, FID), which explains all the product features and costs. To the best of our knowledge, no previous research has scrutinized the process of attention allocation during the reading of these documents and it has not been clarified the influence played by auditory stimuli; therefore, we aim at filling this gap in the literature by analysing individuals' exploratory strategy of FIDs under different auditory conditions (silence, buzzing, music). When bank client read a FID in a bank branch, the environment is not completely silent as there might be the noises produced by other people talking or soft background music. As many bank accounts are explicitly designed for students, we investigated the influence of auditory stimuli on eye-movements and galvanic skin response (GSR), in a sample of 34 students. We observe that the section *Liquidity* is associated to a higher processing time, compared with the

fixed costs and the *variable* ones related to payment services. Adding buzz or music in the background increased the time needed to process each of the document sections, interfering with visual processing. Results are relevant for regulators and bank managers since the detection of any role of auditory stimuli in modulating the attention allocation process towards financial information highlights the importance of disciplining the environmental conditions in which consumers have to observe, read and sign contracts. The paper is organized as follows: Section 2 describes the main theoretical and empirical findings in the literature, Section 3 presents the Methods, describing the sample, research tools and the experimental protocol; finally, Section 4 and Section 5 present the empirical results and their discussion, respectively.

2. Literature Review

In recent years, academics and practitioners have been largely interested in examining how ambiance factors in retail stores can influence consumers' behaviours and retail outcomes (Herrmann et al. 2013; Kaltcheva and Weitz 2006; Morin et al. 2007; Spence et al. 2014), reporting ambiance to be even more important than other in-store factors such as customer service or staff friendliness (Dalziel & Pow; 2014). The study of the link between environmental stimuli and consumers' behaviour has led scholars to produce in the last 30 years a very large body of literature (Bellizzi et al. 1983; Ludvigson and Rottman 1989; Milliman 1982). Recently, a meta-analysis comprising 66 studies and 135 effects has summarized the main findings, revealing a significant role of three factors in affecting shopping outcomes: colour, smell and music (Roschka et al. 2017). Among ambiance factors, music is considered a very important one since it is able to affect consumers' satisfaction, store evaluations, time spent in the shop, time perception, choice and spending (Garlin and Owen 2006; Hagtvedt and Brasel 2016; Kellaris 2008; Knöferle et al. 2012; Milliman 1982; North et al. 1997; North et al. 2016; Spangenberg et al. 2016; Spangenberg et al. 2005; Turley and Milliman 2000). In many contexts such as restaurants, shops, waiting rooms, music is continuously played in the background while consumers are engaged in other activities (North et al. 2003). The music that is played *while* listener's attention is focused on another activity or task is defined background music (Radocy and Boyle, 1988). Music has been studied implementing the experimental conditions in different ways, one of which is to evaluate the effects of the presence and absence of music, comparing dependent variables as customer behaviour (emotions, satisfaction, intentions) across conditions where music is present and where music is absent (e.g., Grewal et al. 2003). Scholars assert that music represents a complementary product or service that is "consumed" during shopping and thus can affect different purchase process outcomes (Hui and Dubé, 1997). Previous studies indicate that the presence of

music (compared to its absence) is positively related to pleasure, to satisfaction, and to behavioural intentions (Roschka et al. 2017). Despite the numerous studies conducted on the link between music and individuals' behaviour, results are still controversial and different effects of the former on the latter have been detected.

As mentioned, the decision-making process comprises different phases and the music can exert its effects on each of them. The phase in which information is visually scanned through the attention function is a crucial moment of financial decisions and thus there is the need to explore the influence of music on the attentional mechanisms. With respect to the information processing phase, opposite effects of the music on individuals' performance have been highlighted. Studies conducted on the Mozart effect (Rauscher et al. 1993), i.e. the changes in cognitive abilities *after* the listening to music, report an improvement of subjects' performance in visuo-spatial abilities when the music had a major mode and a fast tempo (Husain et al. 2002; Schellenberg et al. 2007). Contrariwise, background music has been found to be disturbing and interfering in a large set of situations such as during mathematic tasks (Bloor 2009), surgeons learning procedures (Miskovic et al. 2008), multimedia learning (Moreno and Mayer 2000) and reading (Madsen 1987). The contrasting results on the influence of music on performance can be explained through two different theoretical approaches. According to the "arousal and mood hypothesis" proposed by Thompson et al. (2001), music *directly* affects physiological arousal and emotional states, which, in turns, can have a positive impact on cognitive performance. Studies conducted in neuroendocrinology have revealed that musical stimuli, affecting biochemical substances, as reducing cortisol levels, alleviate and relieve stress (Nater et al. 2006). According to the "cognitive- capacity hypothesis" proposed by Kahneman (1973), music absorbs resources for the brain, reducing its overall efficiency and leading to detrimental performance.

The understanding of the effects of the buzz or the background music on the reading of financial documents is important because a bank customer is exposed to different sources of noise (sound), even simultaneously, and it is in that environment that he decides which contract is more convenient for himself. Visual information processing is a very demanding process for the brain because it relies on the activation and synchronization of several automatic processes like letters identification, semantic access, inference generation, text elaboration (Walczyk, 2000). Listening to buzz or/and music, at different volume (different level of decibels), may interfere directly with this complicated visual information processing, overloading working memory and the ongoing parallel automatic processes. The effects are also related with eventual hypoacusis. Undoubtedly, the individual process of visual stimuli processing depends on whether the buzz and/or music elicit positive emotional states

or negative ones as rejection reactions. All the subsequent decision-making phases bank customers' behavior are influenced by these types of emotions and mental states.

Therefore, we aim to shed light on this issue with respect to the financial domain exploring *the influence of the auditory stimuli on individuals' oculomotor behaviour and galvanic skin response (GSR)* during the reading of financial information contained in the FID.

3. Method

3.1 Participants

39 participants with normal, or corrected to normal, vision and no report of eye or neurological diseases volunteered for the experiments. Data from 5 participants were discarded because eye tracking score for calibration and validation were below the acceptance threshold. The final sample consisted of 34 participants (male = 27) (age: 23 ± 2 years). As we aimed at shedding light on the oculomotor patterns of students who represent a banks' key market segment, subjects enrolled in the experiments are all students who do not have a full-time job. Out of 34 students, 20 already have their own bank account. All subjects gave written informed consent in accordance with the Declaration of Helsinki, after receiving an explanation of the procedure and aims of the study.






3.2. Visual Stimuli and Task

The experiment protocol was created and implemented through iMotions. It was composed of 24 visual stimuli, representing as many couples of FIDs, displayed on a laptop screen for maximum 60s each. Participants were allowed to move forward to the next stimulus as soon as they felt to have acquired all the necessary information, by simply pressing the space bar. This choice was made to prevent subjects' fatigue, or boredom, and a subsequent attention decrease. FIDs have been constructed in such a way that the sum of all costs in one of the two FIDs is lower than in the other. The quantities for computing the variable cost component (which contributes to the total cost) have been derived from the Bank of Italy methodology for computing the bank account *Synthetic Cost Indicator*.¹ The template used to construct the visual stimulus is shown in Fig. 1.

¹ Bank of Italy, Attachment 5A, "*Metodologia per il calcolo dell'indicatore sintetico di costo per i conti correnti*".

Fig. 1. Template of the FID used as visual stimulus.

Which one?

	Account opening	€ 0,00		Account opening	€ 0,00
	Annual fee	€ 0,00		Annual fee	€ 0,00
	Account statement	€ 0,00		Account statement	€ 0,00
	Debit card annual fee	€ 0,00		Debit card annual fee	€ 0,00
	Prepaid card annual fee	€ 0,00		Prepaid card annual fee	€ 0,00
	Home banking annual fee	€ 0,00		Home banking annual fee	€ 0,00
	Transfers v/Italy	€ 0,00		Transfers v/Italy	€ 0,00
	Cash withdrawals at Bank's ATM	€ 0,00		Cash withdrawals at Bank's ATM	€ 0,00
	Cash withdrawals in others banks	€ 0,00		Cash withdrawals in others banks	€ 0,00
	Utility bills payment	€ 0,00		Utility bills payment	€ 0,00

Visual stimuli contained a standard number and type of items, presented in the same order. During the experimental session, each participant was exposed to three different auditory stimuli: silence, buzzing, ambient music. The maximum value of decibels in the buzzing and music conditions is 68. To each experimental condition were associated 8 FIDs defined as blocks, which have been randomized across participants.

To enhance subjects' motivation and assure their active involvement in the visual exploration task, participants were asked to declare, for each couple of FIDs, which one was more attractive.

3.3. Research tools

The SMI REDn Scientific System, equipped with an infrared light source and cameras integrated into a 15.6-inch monitor (1280 × 1024 pixels) was used. The system compensates for head movements within a 50 x 30 cm (at 65 cm distance), allowing the participants to look at the screen in a naturalistic manner. The eye tracking system has a sample rate of 60 Hz, a reported gaze position accuracy of 0.4° and a spatial resolution of 0.05°. The sampling frequency is the number of times per second the position of the eyes is registered by the eye tracker. The higher the sampling frequency, the better the ability to estimate eyes position and their movements. Accuracy represents the average distance between the real stimulus position and the gaze position detected. Spatial resolution, i.e. precision, is a measure of the eye tracker ability to reliably reproduce a measurement. Precision values are calculated as the root mean square of the distance (in degrees of visual angle) between successive samples; for currently available eye trackers, they range from 0.01 to 1 degree (Holmqvist et al. 2011). The testing procedure was performed in a research laboratory. The task was preceded by a 5-point

calibration procedure, which was repeated until calibration was sufficient for each of the data points. Prior to each trial, a light grey slide with a fixation-cross appeared for 2 seconds to reorient attention and ensure that all scanning patterns moved from the centre of the screen. In this study, the eye-tracking parameters are suitable for the detection of the oculomotor behaviour during the scanning of the financial documents and in line with previous studies in neuroeconomics and neurofinance (Rubaltelli et al. 2016; Hüsser and Wirth, 2014; Shavit et al. 2010).

GSR was recorded by means of the Shimmer3 sensor unit (Shimmer3 GSR + Unit; Shimmer, Dublin, Ireland), consisting of a strap, secured to the subject's wrist, and two GSR sensors, placed on the middle and index fingers of the left hand. The GSR sensors recorded both baseline skin conductance levels and skin conductance responses to stimuli.

3.4 Eye Tracking Parameters and statistical procedure

The following eye-tracking metrics were considered:

- *Time-To First-Fixation (TTFF)*: expresses the average interval (ms) from the presentation of the stimulus (start of the trial) to the first gaze fixation on each area of interest (AOI);
- *Fixation Duration (FD)*: is the total duration (ms) of all fixations and saccades within an AOI for all subjects, divided by number of subjects.

Eye-position data were analyzed with a standard area-of-interest (AOI) approach. Rectangular AOIs were defined over six sections of the stimulus: Liquidity, Fixed Costs (FC) Payments, Variable Costs (VC) Payments, both for left and right prospectuses. Eye tracking data were pre-processed using the iMotions software. In the analysis, we considered two dependent variables and for each of it we ran an ANOVA with the AOI type or the experimental condition (music, noise, silence) as grouping variable.

4. Results

We investigated individuals' visual search strategy during the initial phases of financial information selection and processing and the analysis of oculomotor behaviour revealed the following main results.

(1) The analysis by TTFF revealed that subjects visually scanned the documents through a left-to-right path according to the following sequence of sections: Liquidity (Left) – Liquidity (Right) – FC Payments (Left) – FC Payments (Right) - VC Payments (Left) – VC Payments (Right) (Figure 2 and Table 1).

Figure 2. Individuals' scan-path as revealed by TTFF (ms) analysis.

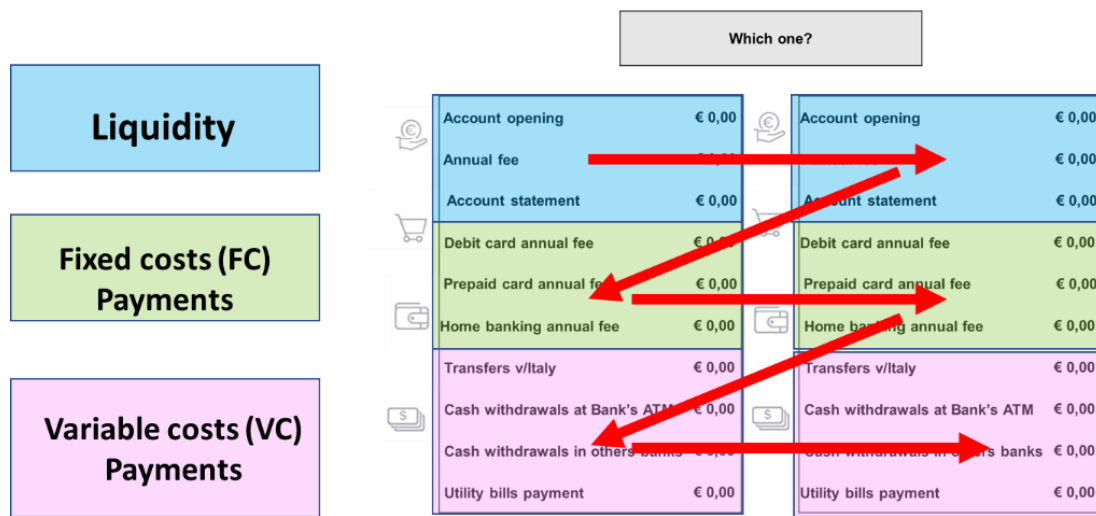
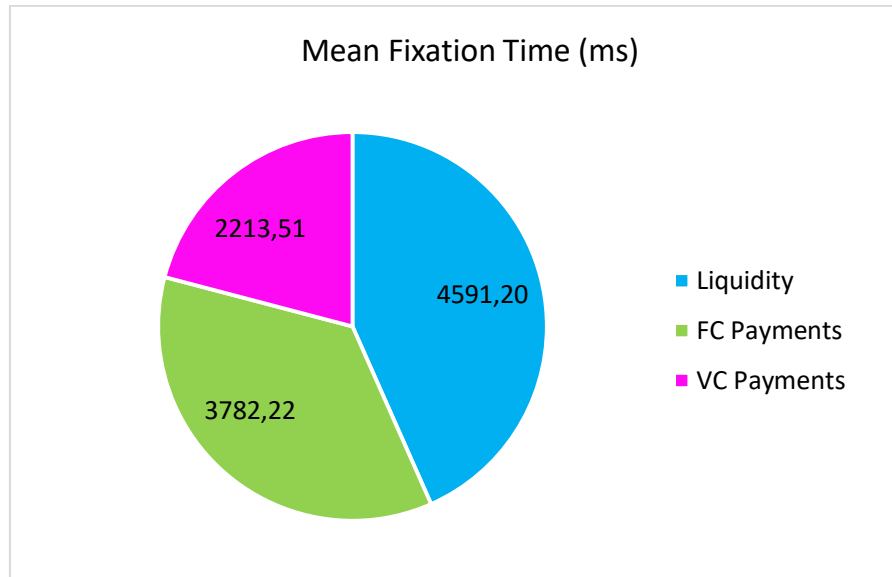


Table 1. Mean, Standard Deviation and Standard Error for TTFF (ms) for each of the AOI

	Mean	Std. Dev.	Std. Err.
Liquidity Left	913,69	2807,43	98,28
Liquidity Right	1001,85	2936,93	102,81
FC Payments Left	7957,07	5568,79	194,95
FC Payments Right	8443,30	5654,74	197,96
VC Payments Left	17059,94	9472,46	331,60
VC Payments Left	17103,27	9759,73	341,66

(2) The analysis of the time spent to process each AOIs was conducted considering the FT (ms) towards aggregated AOIs (i.e.: $FT \text{ Liquidity} = FT \text{ Liquidity Left} + FT \text{ Liquidity Right}$) revealing that *Liquidity* is the source of information which grabs more attention, followed by the section *FC Payments* and finally by the section *VC Payments*, as shown in Figure 3. Subjects allocate their attention equally to the left and right prospectuses.

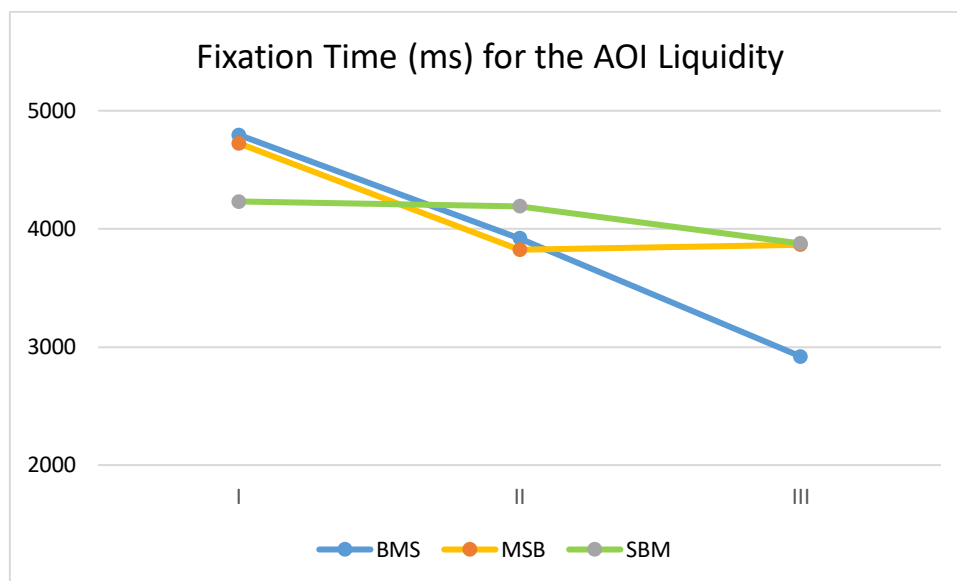
Figure 3. Mean Fixation Time (ms) for each of the aggregated AOIs (Liquidity, FC and VC Payments)



(3) We also observed that attention distribution towards AOIs was *strongly influenced* by the presence of *music* or *buzz* compared with the silent condition. In fact, background music is associated with higher FT, for either Liquidity (mean diff: 720.5, $p < 0.0001$), FC Payments (mean diff: 379.7, $p = 0.0272$), and VC Payments (mean diff: 311.8, $p = 0.01$). Adding buzz in the background elicited the same effects on FT as background music did.

(4) Interestingly, also the sequence of the auditory stimuli affected attentional mechanisms: in fact, the transition from music (M) to silence (S) (sequence MSB and BMS respectively) is associated to higher speed in information processing as revealed by Figure 4. Whether the shorter FT in the silent condition after subjects were exposed to music is the result of more efficacy in information scanning or in lower interest towards the information displayed is going to be elucidated through the analysis of subjects' response on products' attractiveness. The higher number of GSR peaks detected for the music and buzz conditions (M,S mean diff: 0.4, $p = 0.034$; B,S mean diff: 0.5, $p = 0.01$) suggests that auditory stimuli interfere with visual information processing during the reading of financial documents.

Figure 4. Effects of music, buzz or silence on Fixation Time (ms) for the section Liquidity, taking into account the order of auditory stimuli.



5. Discussion and Further developments.

The aim of the present research was to investigate individuals' visual attention allocation during the reading of Payment Account Fee Information Documents. Attentional mechanisms occur below individuals' awareness, and therefore, self-reported measures do not permit to gain insights on these automatic and unconscious processes (Raggetti and Ceravolo 2016, Raggetti et al. 2018). On the contrary, eye tracking, which is able to provide information on investors' brain, detecting, for milliseconds, where the subjects' looked (or not) at and for how long, permits to collect objective and reliable measures of the visual attention allocation process (Fattobene and Ceravolo 2018; Ceravolo et al. 2018).

The analysis of visual search strategies during the reading of FIDs revealed that these financial documents are visually scanned from Left to Right, moving from the top to the bottom part of the document. This scan path reveals that in order to evaluate bank account attractiveness during a comparison process, subjects do not read a whole FID to later process a second one, while they rather prefer to compare information piece by piece. This heuristic might probably facilitate the underlying cognitive process associated to FID comparison but at the same time could be associated to a bias which originates from an analytic approach. To clarify, if subjects evaluate FID attractiveness by comparing each cost item for the correspondent cost item of the second prospectus, they might be prone to formulate their preference through anchoring to a single cost item, disregarding the other

information. For instance, *annual fee* is probably a cost item which greatly affects oculomotor behaviour and judgment (it is included in the section *Liquidity* which has been found to grab the higher attention). If the cost associated to this item is higher in one account than in another and subjects tend to scan the documents in a left-to-right-top-bottom manner, they might fail to integrate other annual fees (debit card, prepaid card and home banking) in their final personal evaluation process. We will shed light on this issue in a following analysis in which we will study subjects' behavioural responses and we will try to disclose whether subjects declared product attractiveness is biased for a single cost item, disregarding the overall total cost of the FID.

Moreover, this finding on the visual search strategy is extremely important since it differs from the one detected for other financial disclosure documents as the *Key Investor Information Document*, where subjects explored information following this pattern: top left – bottom left – top right – bottom right. The existence of differences based on the type of documents and tasks suggest the urgency to expand these study investigating subjects underlying attentional mechanisms for the main and widely used financial information disclosure documents.

This study also highlights that *Liquidity* is the source of information which grabs more attention, followed by the sections dedicated to *fixed costs* and *variable costs* associated to payment services. The ranking in the attention distribution follows the ranking through which sections are displayed to subjects, in the document. This result is in line with a previous study in which it was found that the first source of information in the top-left of the document is the one associated to more attention (Ceravolo et al. 2019a). *Liquidity* might be associated to subjects' interests also because, as mentioned, it contains the *Annual Fee* item. Anyway, the fact that, in a following interview that we conducted after the experiment, subjects rated the variable costs as a crucial information, while it actually gets the lower amount of attention, seems to confirm the relevant and influential role played by the presentational layout.

Finally, in previous studies, Ceravolo et al. (2019a, 2019b) analysed non-professional investors' oculomotor behaviour during the reading of financial documents, observing that factors as the *presentational layout* of the documents and the *colour* in which it is drafted, affect attention distribution across the different sections of the documents. In this study, we contribute to the literature demonstrating that other contextual factors, as *buzz* or *music*, affect individuals' attentional mechanisms during processes, as financial information selection and processing, in which, traditionally, only the content of financial information (i.e. numbers) has been supposed to matter and influence investors. The finding of auditory stimuli interference with visual processing is also

confirmed by the analysis of the galvanic skin response, which revealed a higher number of peaks in the music and buzz experimental conditions, compared with the silent one.

The findings might have several implications for regulators and supervisors. The detection of any role of auditory stimuli in modulating the attention allocation process towards financial information might highlight the importance to discipline the environmental conditions in which investors have to observe, read and sign contracts. Moreover, regulators should place a higher attention in studying the influence of the presentational format and the visual search strategy of financial documents on the product attractiveness evaluations, investigating these links for other financial information disclosure documents as credit card contracts, loan contracts, and so on.

In this research, we focused on University students since they represent a specific banks' target, with respect to the bank accounts segment. In a further development of this study we could test whether these findings differ for adults and whether individual financial literacy modulates oculomotor behaviours, galvanic skin response and product attractiveness evaluations. Moreover, further analysis on this subject could clarify the influence of other characteristics associated to auditory stimuli as the tempo and the volume. The modulation of the number of decibels associated to the music or buzz is likely to influence individual brains' reactions to auditory stimuli. This intuition will be tested in an analysis, already in project, in which we will explore subjects' behaviour by means of eye-tracking, EEG and fMRI, considering a complicated and variable mix of different factors that modulate the bank client's decision-making process. In particular, we will explore the influence on subjective preferences about financial contracts, played by the layout of the FID, the use of colour, the auditory stimuli in the environment, in which there can be silence (as in a private home where it is possible to eliminate noises and music), buzz or music in the background, considering total costs, the quality and quantity of services included in the contract. In addition, it could be interesting to explore whether these findings can be extended to other contexts, as when bank customers process FIDs alone at home.

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