Coloured layouts affect financial information processing

Abstract

This study examines whether investors are sensitive to the colour used to print the Key Investor Information Documents (KIIDs) and whether this influences the financial attractiveness of products. In order to observe and measure investors' attention, the authors exploit the unobtrusive methodology of eye tracking on a sample of nonprofessional investors, applying an ecological protocol, through a cross-sectional design. The analysis reveals that financial information processing and attention distribution are influenced by the colour of the KIID document, as *red* layouts seem to attract focused attention more than *blue* layouts and to push investors to rate the products as less financially attractive, especially when the product risk-reward indicator is high. This suggests the importance of studying the unconscious neural mechanisms of information processing in the first seconds of scrutiny of financial product documents. Eventually, results lead to recommend regulators and financial managers to understand how investors respond to particular aspects of financial disclosure documents based on neuroscientific studies.

Keywords Investor's behaviour, Attention, Eye tracking, Neurofinance

1. Introduction

The Key Investor Information Document (henceforth KIID) is a plainly worded, two-A4 page document, recently introduced by the UCITS directive, to foster harmonisation of pre-contractual information and "*to raise the level of investors' protection*". The document is supposed to facilitate comparability of financial products across Europe and to provide investors with all relevant information to take responsible decision. With this aim, the UCITS directive has established in minute details the structure of the KIID, which has to consist of the following sections: investment objectives and policy of the fund, risk-reward indicator of the investment policy, all costs and charges associated with the product, its past performance, and other practical information.[1] However, regulators have not yet established the colour in which the document should be printed, so that, currently, KIIDs are printed and issued in different colours (blue, red, green, orange and so on).

At the same time, research in neuroscience reveals how most brain processes occur in an automatic and unconscious way, with even the highest cognitive functions, like the decision-making process, being potentially modulated by subtle variations in the information conveyed to the brain and processed by different and several neural structures (Schmidt, 2013; Camerer, 2005; Damasio 1998; Le Doux, 1996). Researchers in various disciplines are offering these knowledges. An interdisciplinary approach is usual in neuroeconomics which aims at studying the neural bases of the decision making process and individual's behaviour in the economic and financial domains (Frydman et al., 2014; Glimcher and Fehr, 2014; Knutson et al., 2007; De Martino et al., 2006; Hsu et al., 2005). The phase of reading is a complex process for our brain and consists, shortly, of the following phases: i) collection of *chemical* and *physical* stimuli from the environment through the sensory system, ii) filtering of the stimuli through the mechanism of attention, iii) transmission of the stimuli from the

[1] The template is provided in the CESR/10-794 consultation paper.

retina through the optic chiasm to the visual cortex, iv) perception, categorization and conscious interpretation of the information.

Phase two (the selection of visual stimuli, hence of the information) is modulated by unconscious mechanisms, that may vary depending on the individual past experience, or be genetically determined, like the response to the shape, position and colour of the visual stimulus. In this research, we sought to study this phase of information processing, which starts in the very first milliseconds after the stimulus is presented to the subject. The reading of financial disclosure documents is strictly controlled by the neural function of *attention* that is responsible for selecting the information that will be processed by the brain, filtering it from the abundance of environmental stimuli, in the time frame of milliseconds. The disclosure document of the KIID has been delineated based on multiple traditional tests carried out with focus groups, surveys and telephone interviews. These methodologies do not allow to open the black box of the decision making process, understanding the process of attention allocation during the reading of disclosure document, since they suffer from several biases as the lack of introspective access to affective and cognitive resources and the tendency to over-attribute behaviour to controlled processes. Conversely, the study of the oculomotor behaviour, with the eye-tracking methodology, helps to solve this issue, revealing the unconscious visual scanning strategies and the automatic process of attention distribution over the information sources (Luna et al., 2008).

According to a bottom-up saliency-based theory, visual attention is driven by low-level visual features such as the colour (Itti and Koch, 2000). In finance, the use of colour to represent visual data and information has a long history. Coloured stimuli are spread in all trading platforms accessed by professional and private investors: OptionsHouse, Fedelity, Lightspeed Trader, Bloomberg, and other online platforms adopt the colour in order to represent the important information for investors. Research conducted in different field such as neuroscience, psychology, aesthetics, marketing, and communication suggest that coloured stimuli carry communication values and, in particular,

individuals tend to associate *red* with *danger* and *blue* with a *secure sensation* (Wright, 1988; Mahnke, 1996; Fraser and Banks, 2004; Bagchi and Cheema, 2012).

In the light of the above, the goal of this research is to investigate the role played by colours (blue vs red) on attention allocation during the reading of financial disclosure documents and the subsequent phase of rating the financial attractiveness of these products. We exploited what is considered the most adequate neuroscientific tool to study the unconscious process of attention, i.e. the eye tracking methodology, which allows detecting the locus of eye fixation[2], the average duration fixation, total fixation time, and the scan path, of the initial phase of stimuli visual scanning. Eye movement data constitutes a way to study neural function since they can provide valuable information about both cognitive and affective processes (for a comprehensive analysis of the eye tracking methodology, please see Holmqvist et al., 2011).

Results reveal that the colour of the layout plays a role in modulating both individuals' attention and the following perceived attractiveness of financial products. The red colour has been found to grab attention for longer time than the blue colour, especially for the following information: Risk-Reward Indicator (IRR), last ten-years product performance, product performance in 2008-2010 (the last financial crisis) and the disclaimer which underlines how past performances are not predictive of future performance. Finally, the colour used for the layout influences products financial attractiveness. For KIIDs with high IRR, the red colour induces participants to consider a greater proportion of financial products as poorly attractive, than the blue colour.

This research is relevant to the literature in different ways. Firstly, we observe that the colour of the documents' layout influences attention allocation with the red colour attracting more attention and driving a greater spontaneous visual focus to some information sources. Secondly, we challenge the traditional view of the perfectly rational investor, demonstrating that even the smallest details in the

[2] Fixations are period of time when the eye is stationary and gather visual information, while saccades are fast ballistic movements that redirect gaze. The scan path is defined as the sum of fixations and saccades.

layouts of the financial disclosure documents can affect products attractiveness; hence we claim that authorities and regulators should consider neuroscientific knowledge and the unconscious physiological mechanisms that underlie the decision-making of the final recipients of the communication, when designing financial documents. Finally, we propose the eye-tracking methodology as a new instrument to integrate regulators and policy-makers toolkit box.

The remainder of the paper continues as follows: Section 2 describes the literature review, Section 3 reports on the method, Section 4 illustrates the results and the discussion is provided in Section 5.

2. Literature Review

Previous studies have shown that visual cues, such as colour, convey affective information, thus having an impact on the processing strategy and the decision-making process. Colour influence on cognitive and affective processes is a significant topic in literature (Bellizzi et al., 1983), and some studies (Elliot et al., 2007; Elliot and Niesta, 2008; Schlack and Albright, 2007) support the idea that the models of semantic memory such as the associative network theory (Bower, 1981) explain the formation and activation of colour associations. Although these studies are restricted in the number of colours and types of emotions and associations they test, the effects of colours remain relatively consistent across studies, which provide some empirical evidence of a systematic relationship between colour and emotions (Levy, 1984) and cognitive function (Elliot et al., 2007). In a neuroscientific study, Schlack and Albright (2007) find that the associative learning of visual information develops during early stages of visual processing as a key mechanism for quick decision-making and survival. For this reason, colour is considered an important variable also in the marketing literature: it is capable to affect consumer perceptions of advertising (Gorn et al., 1997) and product category membership (Bottomley and Doyle, 2006) and to alter perceived website loading time (Gorn et al., 2004). For instance, Labrecque and Milne (2012) demonstrate how marketers can strategically use colour to alter brand personality and purchase intent, and how colour influences the likability and

familiarity of a brand. The results underscore the importance of recognizing the impact of colour in forming consumer brand perceptions.

From a theoretical perspective, there are two explanations for why colours carry communication values that may be expected to affect behavior: an evolutionary biology explanation and a social learning explanation.

An *evolutionary biology explanation* implies that colour associations emerge from genetically ingrained responses to critical fitness-relevant colour stimuli in an individual's environment. For example, red is the colour of many objectively dangerous phenomena that individuals encountered, such as blood or fire (Changizi, Zhang and Shimojo, 2006), while, at the contrary, blue is seen as a secure colour (Murray and Deabler 1957; Schaie 1961; Wexner 1954), associated with the water and the sky which generally represent positive phenomena.

According to the *social learning explanation,* colour associations have an impact on human behavior because of repeated pairings of a colour with particular concepts and an individual's experiences (Elliot and Maier, 2012). In many cultures, the negative perception of red colour starts in early schooling as students receive feedback regarding academic errors in red (Elliot, Maier, Binser, Friedman and Pekrun, 2009) and associate the colour with alarms and stop signs that convey danger and command enhanced attention. Oppositely, blue is associated with security, trust, efficiency, duty and logic (Fraser and Banks, 2004; Mahnke, 1996; Wright, 1988), and as "cool" colour, it evokes more positive evaluations than "warm" colours (i.e. red). Bagchi and Cheema (2012) posit that blue in comparison to red background colour leads to more positive purchase intentions for specific categories of products. Colours have also an influence on information processing: according to Madden et al. (2000) and Ettis (2017), blue facilitates information processing, positively influencing information seeking.

The influence of colour on behavior has been studied also with respect to investors. Bazley, Cronqvist and Mormann (2017) observe that when investors are displayed potential losses in red, risk taking is

reduced. Moreover, they report that when investors are shown past negative stock price paths in red, expectations about future stock returns are reduced. Consistent with red causing "avoidance behavior," red colour reduces investors' propensity to purchase stocks. The findings are robust to a series of checks involving colourblind investors and alternative colours to control for salience effects. The efficacy of the recently introduced KIID has been investigated already from some studies. Walther (2015) compares the new KIID with the old Simplified Prospectus and report that quality perceived is higher for the former and the information overload is lower than for the latter. Hillenbrand and Schmelzer (2015) have analysed the influence of a visual distractor on the document and report that it leads to gather less correct information. To the best of our knowledge, no previous academic studies, neither research carried out by authorities have tested the influence of background colour on the process of attention allocation during the reading of the KIID. On these premises, we aim to study the underlying physiological mechanisms of the information processing of financial disclosure documents, testing whether and how the background colour of the documents influences the process of attention allocation over different sources of information and the subsequent phase of products' financial attractiveness perception. To this aim, we propose the unobtrusive methodology of the eye tracking, largely used in neuroscience to study attention mechanisms, that measuring eye-muscle movements provides knowledge and indices of brain function and affective and cognitive processes. Visual field present several stimuli at the same time and the brain ability to process them is limited, therefore stimuli are filtered and irrelevant information is dropped (McMains and Kastner, 2010). Measuring the locus of the eye fixation and the total fixation time inform us about individual's overt attention and how the characteristics of the stimulus, such as the colour, influence the flow of information in the brain, through the visual system. The traditional self-report methodologies would not permit this depth in the investigation, given individuals' inability to detect phenomena that occur automatically and below awareness level. The eye-tracking methodology, by using infrared light to measure very small eye movements, offers objective parameters about exploration pattern.

3. Method

Eye-tracking device

Eye movements were recorded using the SMI REDn Scientific (SensoMotoric Instruments GmBH, Berlin, Germany) system, contact-free eye tracking that allows head movement compensation. The processor to record gaze data is located in a dedicated computer, embedding the eye tracker. The system includes a 15'' monitor that ensures non-invasive data collection, since subjects do not have to wear special eye-tracking glasses, which in turn, could affect behaviour. The sampling rate was 60 Hz. The system has a spatial resolution of 0.05° and a gaze position accuracy of 0.4°. Participants were seated at a distance of 60-80 cm from the 15.6'' laptop (screen resolution: 1366 x 768; grey background). Before each test, the device was calibrated using the software's 5-point monitor calibration.[3] SMI REDn Scientific is also highly robust for vision corrections (glasses and contact lenses).

Participants

Participants were recruited during April 2018 through a call, posted on a major University bulletin board. A window of no more than two weeks was selected in order to ensure rigorous data collection, avoiding students telling other participants about the experiment. Inclusion criteria were: a) age lower than 28; b) calibration score above the acceptance threshold; c) written informed consent to the investigation. Exclusion criteria were: a) colour blindness, b) impaired visual acuity in any eye, c) strabismus; d) any other acute or chronic eye disease; e) any investment experience in financial products. In order to rule out visual acuity impairment or colour blindness, we ascertained that subjects had undergone at least one ophthalmology appointment in their life. Moreover, we interviewed them to ascertain that they had never read a KIID until that moment, were completely

[3] Calibration is necessary in order to control for eyeball radius and shape, ensuring maximal data quality.

unfamiliar with the disclosure documents and, eventually, did not have any investment experience in financial products. This allowed to rule out any influence of students' cultural background, guaranteeing a homogenous sample of nonprofessional investors.

Participants were given a brief introduction about eye tracking data recording and were informed about their rights and the experimental procedure.

Task and procedure

The study protocol implies the presentation of 18 consecutive slides, displaying as many different KIIDs, for a maximum of 60 seconds (s) each. Out of the 18 slides, 9 are red and 9 are blue and the distribution followed a random order. Before each trial, a fixation cross appears in the centre of the screen (approximately 1 cm × 1 cm). The trial starts automatically if the participants fixate their gaze on the cross for at least 500 ms. This is to ensure that every participant would be looking at the centre of the stimulus display at the beginning of the trial. The participants are instructed to move to the next trial, pressing the space bar, as soon as they feel ready to rate the financial attractiveness of the product: this avoids that they keep wandering with their eyes on the screen when they have completed the visual information scan. After each slide displaying a KIID, a slide follows questioning the participants about the financial attractiveness of the product: in particular, they are required to rate the product as "Low", "Medium" and "High" financially attractive, using the laptop mousepad.

Figure 4 synthetizes the experimental procedure. The structure of the KIIDs used in this study follows the UCITS directive and consists of the following sections: i) investment *objectives* and policy, ii) risk-reward indicator (*IRR*), iii) costs and charges, and iv) past *performance*. The blocks of information occupy the four quarters in the screen. The fifth section established by the directive – *practical information* – has been excluded since it discloses the name of the financial institution offering the product. Such information is associated to the institution's image and reputation that, in turn, can elicit affective reactions and modulate the perception of the convenience of the product.

Moreover, previous studies have demonstrated that logo firm-related elements, such as logos, banners and colours, represent visual distractors (Hillenbrand and Schmelzer, 2017). In order to provide standard documents and ensure scientific validity, different precautions have been taken. In more detail, the stimulus background is white and the information is written in black with a constant font size of 12; the graphical elements are in grey. Colours, blue and red, have been applied to the IRR section and the performance section. In written-text sections, the number of text lines is always the same across different stimuli, to ensure the comparison of eye tracking variables across the trials. The time period to which past performance refers always consists of 10 years, in line with Commission Regulation (n.583/2010) implementation of the Directive (2009/65/EC) which establishes that "the information about the past performance of the UCITS shall be presented in a bar chart covering the performance of the UCITS for the last 10 years". We fix the interval of the 10 years to the period ranging between 2008 and 2017, for all the KIIDs. An identical time span ensures that people do not infer other information, which in turn might influence their behaviour (i.e., if past performances would be presented up to 2013, subjects could deduce that the fund is not profitable and not present on the market any longer, thus lowering their perceived convenience). In the seven-point scale of the risk-reward indicators, the classes 1 and 7 have never been selected to avoid anchoring effect driven by extreme values.

Figure 1 synthetizes the experimental procedure.

< Insert Figure 1 about here >

Outcome measures and data analysis

The eye-tracking analysis software allows the extrapolation of several quantitative variables describing the spatial and temporal parameters of gaze. Moreover, it is possible to divide the presented stimulus into different areas of interest (AOIs) in order to better understand the influence of different features of visual information on attention allocation. We chose to divide each slide into *four main*

AOIs corresponding to the four KIID mandatory sections. We also detected *four minor AOIs* as follows: the years *2008-2010,* representing the product trends through the years of the global financial crisis, the years *2015-2017*, showing the performance of the latest years, the *disclaimer*, informing financial consumers that past performances are not predictive of future returns, and the graphical *risk scale* in the IRR sections that ranges from 1 to 7.

We analysed the following gaze features:

- Entry Time: expresses the average interval (in milliseconds - ms) from the presentation of the KIID document (start of the trial) to the first gaze fixation on each area of interest (AOI). It may be considered as a proxy of the relevance of information for the individual subject and allows tracking the scan path that is the sequence by which the document is visually scanned by each subject.

- End Trial Time: expresses the average time interval (ms) between the presentation of the KIID document (start of the trial) and the participants' answer. It synthetizes average trial duration.

- Net Dwell Time (NDT): represents the sum of net dwell time of all subjects divided by the number of subjects.

The Analysis of Variance has been used to compare the distribution of outcome variables by areas of interest and presentational format.

4. Results

Fifty-three students (thirty-four males, nineteen females) agreed to join the study. Five of them were excluded based on the eligibility criteria. The mean age of the 48 enrolled subjects (thirty males, eighteen females) was 23 years (± 2). A total number of 864 observations were collected, as result of 18 stimuli presented to each participant. The sample size is in line with many previous studies conducted using eye tracking (i.e.: Djamasbi, Siegel and Tullis, 2010; Sharif and Maletic, 2010; Davenport, 2007).

In this section, the relationship between colour layout, attention distribution and perceived attractiveness of the products is described.

Our analysis reveals that the layout colour modulates the attention dedicated to the reading of the KIIDs. We observe that the overall time dedicated to the screening of the information is higher when the colour layout is red than when it is blue, as revealed by the Export End Trial Time variable (39.39 s ± 14.16 s and 43.06 s ± 13.67 s) ($p < 0.0001$). The value added by the methodology of the eye tracking is the increase in the level of detail of the analysis by the quantification of the attention distribution over the different source of information. With respect to the IRR area, results show that the variable colour is able to modulate individuals' attention and the colour red attracts more attention than the blue, as proxied by the NDT (9.02 s ± 6.18 and 7.49 s ± 5.71) ($p < 0.0008$). Moreover, a considerable modulation of attention induced by the colour variable is observed for the part of the KIID which displays the past performance (NDT for red layout: 9.44 s ± 7.07 s; NDT for blue layout: 7.78 s ± 6.26 s) ($p < 0.0012$), and for the AOI that refers to the years of the crisis (NDT for red layout: 1.97 s ± 2.1 s; NDT for blue layout: 1.49 s ± 1.73 s) ($p < 0.0011$). Interestingly, we detect a role of the colour in attracting individuals' attention also for the minor AOI of the disclaimer (NDT for red layout: 1.7 s ± 2.06 s; NDT for blue layout: 1.3 s ± 1.66 s) ($p < 0.0051$). For other main sources of information as the quarter of the document related to the objectives and the costs and charges, we do not observe any statistically significant role of the colour in modulating attention. It is worth to underline that these two AOIs, contrary to the other parts of the documents, do not display a coloured background, since they are black and white.

The graphical representation of the variable Entry Time (ms) in Figure 2 reveals that the way individuals scan financial documents is not sensitive to the layout colour, i.e. the colour blue and red do not lead individuals to a different gaze behaviour in exploring the documents.

< Insert Figure 2 about here >

We performed a series of robustness check to ensure these results were not provided by only one eye-tracking outcome variable. Results are confirmed for the following other eye-tracking outcome variables: Fixation Count and Fixation Time.

In a following step, we analysed the relationship between the layout colour and subjects' perception of financial attractiveness, with respect to KIIDs displaying either high, medium or low IRR scores.

< Insert Figure 3 about here >

As charted in Figure 3, when the IRR of KIIDs is high, the blue colour is associated with a higher proportion of products rated as highly financially attractive (41%) than red colour (14.6%). Interestingly and symmetrically, red colour is associated with a significantly higher proportion of products rated as poorly attractive (59%) than blue colour (24%). This difference is maintained even after controlling for the IRR variable. Such result confirms the power of red colour at conveying a warning message that can lower the financially attractiveness perception; conversely, the blue colour seems to send a reassuring message that can raise the financial products' attractiveness.

< Insert Figure 4 about here >

As displayed in Figure 4, this influence of colour on products' attractiveness is also confirmed for KIIDs with low IRR scores. In more details, the proportion of products rated as highly attractive when the layout is blue is 41% against the 25% in case of a red layout. At the same time, the proportion of products perceived as poorly attractive when the layout is red is 37%, against the 17% of the blue-layout.

< Insert Figure 5 about here >

Finally, as shown in Figure 5, for KIIDs with medium IRR values, the influence of the colour on financial products' attractiveness is still detected but the effect is softened. In a neuroeconomics perspective, this result is particularly challenging since medium values of IRR could be considered a situation of ambiguity and recent studies have reported that when the context is ambiguous, the brain is more prone to produce a biased judgement and use heuristics to solve the impasse.

5. Discussion

In this research, we sought to investigate whether the layout colour of the KIIDs plays a role in affecting individuals' process of attention allocation and the subsequent phase of evaluation of products' financial attractiveness. To this aim, we adopt an interdisciplinary vision, which bridge neuroscience and economics, in order to overcome the limitations of the traditional methods such as questionnaire, focus group and interview, which are not able to convey information about the unconscious and automatic processes of the brain. On the contrary, the eye tracking, allows to study the influence, which occurs below the awareness level, of some features (i.e. colour layout) on the decision making process and in particular, on the visual exploration phase, through reliable estimation of neurophysiological variables.

The results of our analysis reveal that colour layout modulates attention distribution and influence products financially attractiveness. We observe that the red layout attracts more attention for the following sources of information: performance, years of the crisis, IRR, and disclaimer. Moreover, we detect a higher proportion of products perceived as poorly attractive when the layout is red, for either low, medium or high IRR.

This study is relevant in different ways. In the first place, it informs regulators and policy makers of the importance of considering the colour of disclosure documents as an element able to influence behaviour unconsciously. Therefore, we suggest the need to study layout features when design the products, through neuroscientific approaches which manage to overcome individuals' limitation of reporting neural processes which occur below the awareness level. To this aim we endorse the eye tracking as a necessary instrument in the authority toolkit when studying disclosure documents.

The study has some limitations.

Firstly, the experiment task consists in rating products attractiveness but do not actually buy any products. Previous studies have largely demonstrated how the task and the use of either own and real resources influence the decision making process (Raggetti *et al.,* 2017; Ayaz *et al.,* 2013; Ariely and

Berns, 2010). Secondly, we do not distinguish for subjects' different levels of financial education, statistical ability, risk aversion, and therefore different samples of participants should be analysed in order to study the influence of other variables and the generalisation of the results.

Further developments of the study could be the investigation of the influence of the background colour, rather than the colour of specific source of information, on attention distribution. Moreover, the effects might be different in a cultural setting, e.g., China, where red is not used to visualize financial losses.

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Figures.

Figure 1. Experimental design

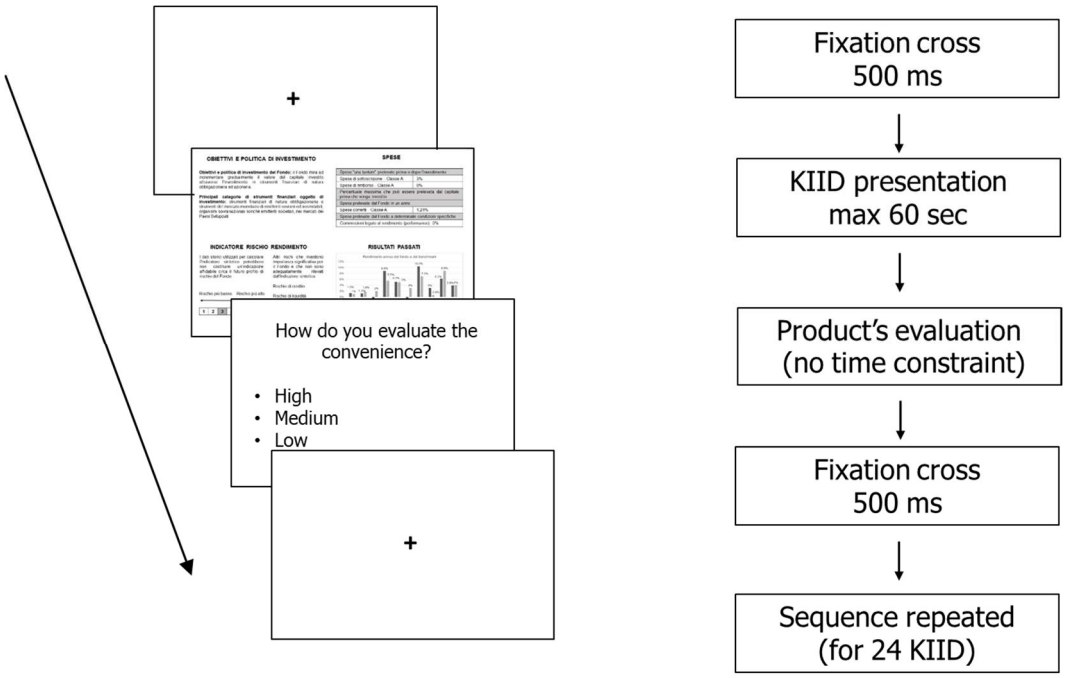

Figure 2. Scan path of the KIIDs

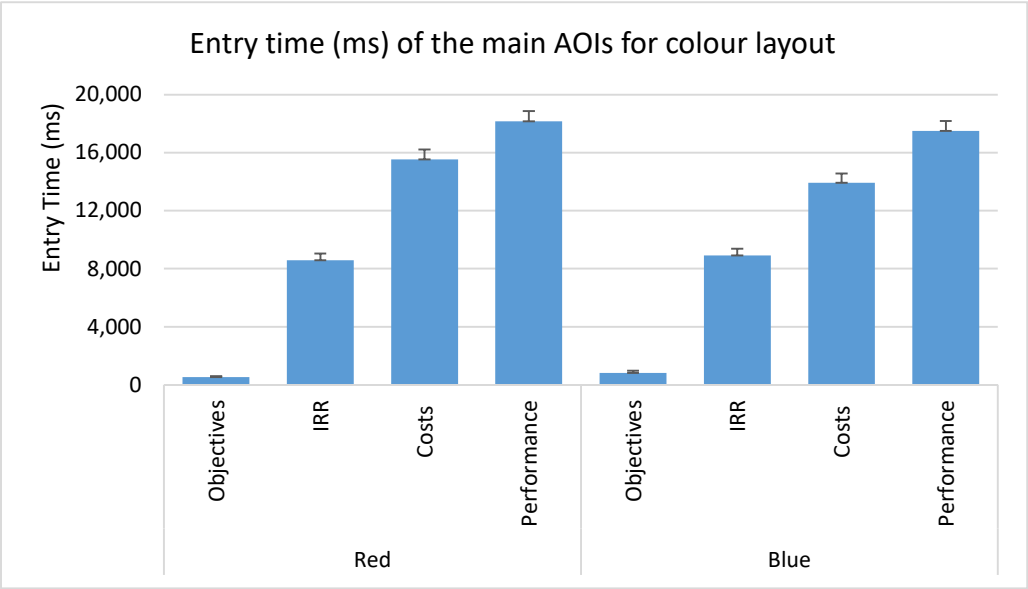

Figure 3. Proportions of high IRR products perceived as poorly, medium or highly attractive, according to the layout colour

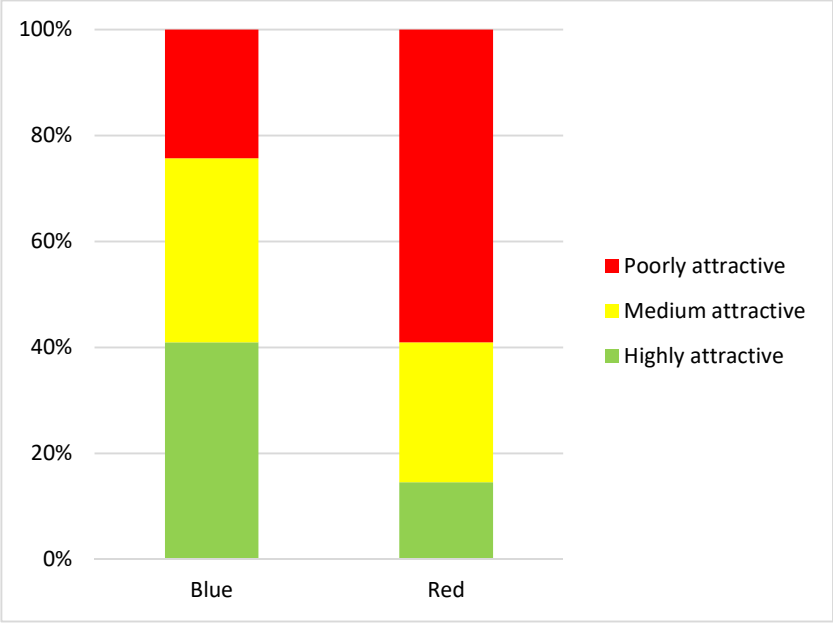

Figure 4. Proportions of medium IRR products perceived as poorly, medium or highly attractive, according to the layout colour

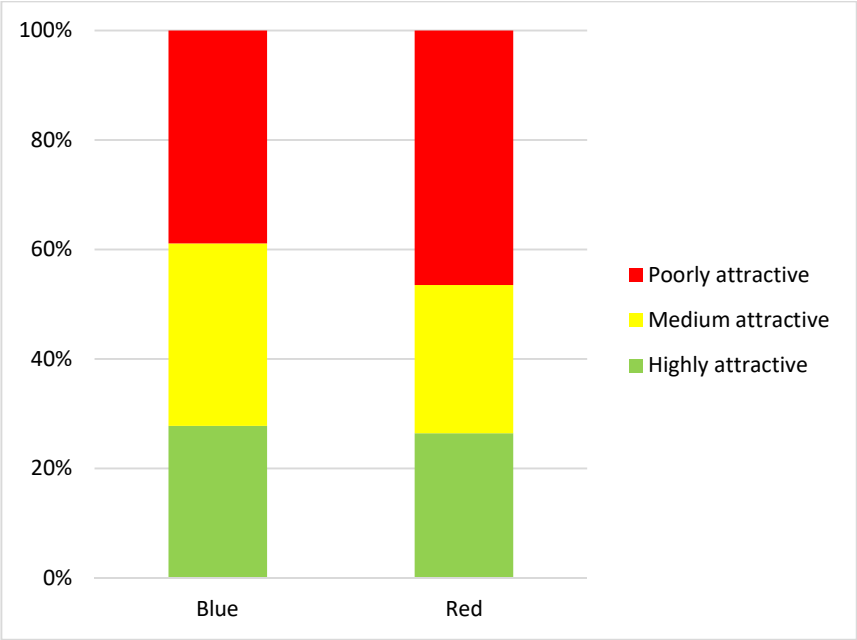
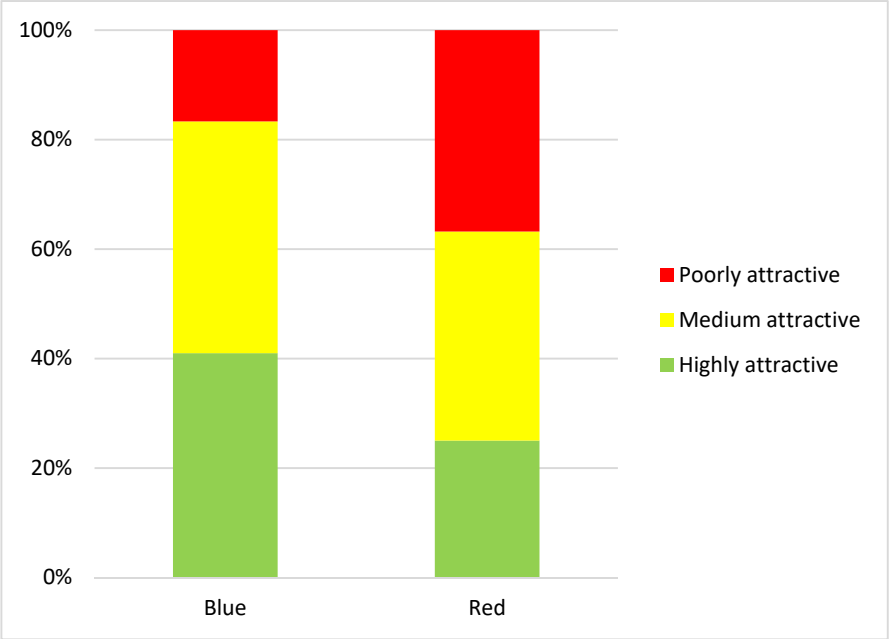
Figure 5. Proportions of low IRR products perceived as poorly, medium or highly attractive, according to the layout colour