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Time to pay attention to attention: using attention-based process traces to better understand consumer decision-making

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Abstract

This paper examines consumers' *attention traces* (e.g., sequences of eye fixations and saccades) during choice. Due to reduced equipment cost and increased ease of analysis, attention traces can reflect a more fine-grained representation of decision-making activities (e.g., formation of a consideration set, alternative evaluation, and decision strategies). Besides enabling a better understanding of actual consumer choice, attention traces support more complex models of choice, and point to the prospects of specific interventions at various stages of the choice process. We identify and discuss promising areas for future research.

Keywords Attention · Choice · Consumer · Decision-making · Evidence accumulation models · Process tracing

Consumers continuously acquire information as they make decisions. They do so via a series of eye fixations and saccades, which we label *attention traces*. We propose that specific attention traces can be identified and sorted into a taxonomy that maps onto specific decision processes, such as screening, interpreting, and evaluating information during choice. Developing such a taxonomy will allow researchers who are embarking on the study of attention, or are adding attention monitoring to their existing research toolbox, to use the same terminology, constructs, and measures as other researchers. A taxonomy will also provide opportunities to construct more dynamic, and detailed, choice models. Ultimately, these enhanced models of choice should help us to more accurately predict choice.

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1 Attention tracing for decision research

The cognitive revolution of the 1960s invited process-based accounts of decision-making phenomena and, consequently, the development of process-tracing methods (see Online Appendix for a brief, historical summary of process tracing research). Present-day studies using attention traces both extend this tradition and, at the same time, benefit from four trends. First, an ongoing decrease in the cost of attention-monitoring hardware has enabled more researchers to use attention traces. Second, there are more opportunities to gather these data in realistic environments, and lab-based researchers can create virtual environments to acquire more nuanced data about consumer attention in the marketplace. Third, the increase in the number of decision researchers studying attention has been paralleled by an ongoing increase in the expertise available to design, execute, and analyze attention trace data. Finally, choice theory itself is becoming more flexible. Current models expand upon prior models by allowing information availability and decision-process fluency to direct decision-making. For further details on eye-tracking research, see Wedel and Pieters (2017), Orquin and Loose (2013) and Russo (2019)[1].

2 Attention traces at different stages of the decision process

We organize our discussion of the relationship between attention and choice around the following stages of the decision process: awareness, screening, evaluation, and choice execution (Table 1). These stages are used as natural categories, with no assumption that they follow a rigid sequence. For each one, we briefly summarize current knowledge, highlight open questions for future research, and suggest methodologies for answering these questions.

2.1 Awareness

Awareness typically involves monitoring the environment for opportunities (Carrasco 2011). In consumer choice, awareness begins by learning what products are available. This knowledge is achieved via both bottom-up activities (e.g., attention drawn by physical characteristics of products) and top-down ones (e.g., active search driven by the individual's personal goals and preferences). In a purchase environment, these bottom-up and top-down processes make salient certain locations and their corresponding objects of regard. Thus, a box of crackers may be salient due to *colors* that pop out from the rest of the shelf and/or because the consumer is searching for her *favorite* box of crackers (Mormann, Towal, and Koch 2015; Milosavljevic et al. 2012). As shown in Fig. 1a, at this stage, attention is characterized by short, non-repeated, dispersed fixations (i.e., broad sampling). That is, a product will typically receive no more than one short fixation, and the set of fixations is broadly distributed.

[1] These developments coincide nicely with increased awareness by researchers that visual attention and memory cannot be equated and that better measures of attention are needed (Milosavljevic and Cerf 2008; Chandon et al. 2009; Aribarg, Pieters, and Wedel 2010; Atalay et al. 2012).

Table 1 Recommended methods for examining attention traces and choice processes

Research questions	Suggested methods/measures	Further readings about methods
Awareness		
Which factors increase awareness of an alternative (e.g., physical characteristics of packaging, goals and preferences, violating expectations about a product display, reducing visual search costs)? How does prior knowledge of the display structure of the retail environment influence awareness? When and how do consumers move from the awareness stage to screening and consideration? What does the attention trace look like for the awareness stage?	Eye-tracking and clickstream: Which items are clicked on/looked at first, second, and so on; number of different products examined. Computational algorithms of salience and bottom-up attention: Which locations/objects are most salient? How does attention deviate from predicted attention by computational algorithms? RFID and video data: Time at the display before the first touch; number of product touches.	Wedel and Pieters (2017); Russo (2019); Orquin and Mueller Loose (2013); Willemsen and Johnson (2019); Moe (2003) Milosavljevic and Cerf (2008) Zuo (2016)
Screening		
Which factors sustain attention to an alternative so to encourage screening (e.g., physical characteristics of packaging, particular features)? Which factors encourage "processing loops," where a consumer "circles" between awareness and screening (e.g., avoiding grid layouts, uniform product sizes, uniform visual depth, placing visually salient items at dispersed areas of the choice set)? Are there differences in the distance between shopper and shelf during the awareness vs. screening stage? What are the implications of these differences for downstream behavior? When does screening lead to evaluation? What does the attention trace look like for the screening stage?	Eye-tracking and clickstream: Average fixation duration; fixation within an alternative vs. between alternatives; average saccadic distance; maximum saccadic distance. Body position, body movement and touch (e.g. measured in virtual reality): Distance between shopper and display/shelf. RFID and video data: Duration of touch per alternative.	Wedel and Pieters (2017); Russo (2019); Orquin and Mueller Loose (2013); Willemsen and Johnson (2019); Moe (2003) Hui et al. (2013) Meissner et al. (2019) Zuo (2016)

Table 1 (continued)

Research questions	Suggested methods/measures	Further readings about methods
How do attention traces differ between screening and consideration?		
Evaluation		
How can choice environments be (re)structured so that attention is sustained long enough to initiate a deliberate evaluation process? How does the order of processing information influence the use of comparative processes? Which factors increase the likelihood of specific comparison processes or cognitive representations (e.g., proximity of stimuli)? How can interruptions or distractions be inhibited? Can attention traces inform recommendation systems? What is the role of perceptual fluency in brand evaluation processes? What are various attention traces that occur during the evaluation stage?	Eye-tracking and clickstream: Average duration a product is viewed; maximum number of revisits; number of subsequent visits to areas of interest within an alternative. Verbal protocols: Consumer verbalizes the process; self-reported nonattendance. RFID and video data: Duration of the consideration; number of product touches.	Wedel and Pieters (2017); Russo (2019); Orquin and Mueller Loose (2013); Willemsen and Johnson (2019); Moe (2003) Ericsson and Moxley (2019) Zuo (2016)
Choice execution		
Which attention traces indicate post-choice uncertainty and/or the abandonment of a tentative purchase?	Eye-tracking and clickstream: Number of switches between choice alternatives; duration of how long items have been in the shopping basket.	Wedel and Pieters (2017); Russo (2019); Orquin and Mueller Loose (2013); Willemsen and Johnson (2019); Moe (2003)

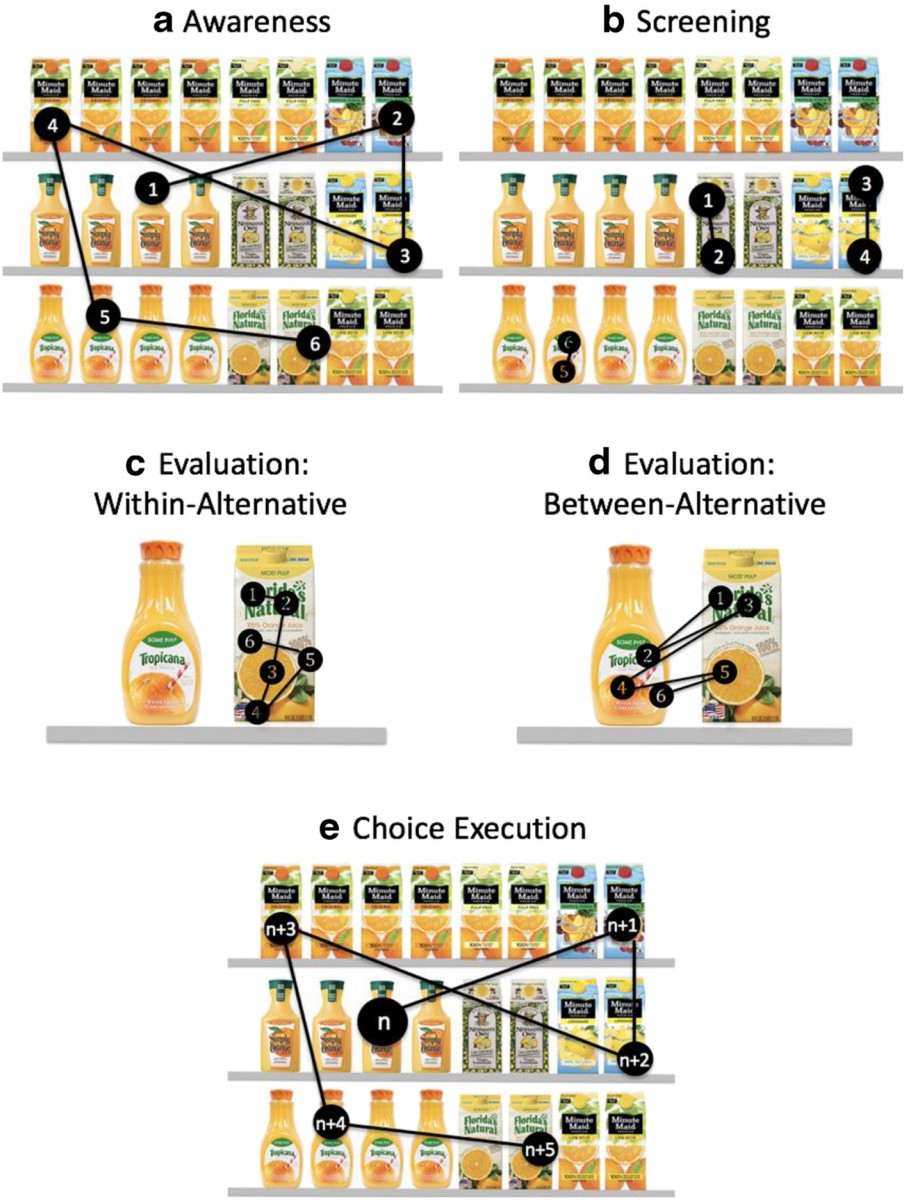

Fig. 1 Attention traces associated with different decision-making stages. Note: circles signify eye fixations, with numbers indicating order of fixations. Black lines between fixations signify saccades. In the "Choice Execution" stage, "n" signifies fixation on the selected alternative

2.1.1 Awareness stage research opportunities

Because awareness is necessary for all subsequent processing, research should focus on identifying strategies for gaining awareness of the most likely candidates to be the eventual best choice. Awareness can be encouraged by restructuring the environment

(e.g., a retail store) so that it promotes interest, learning and discovery, and opportunity to engage (e.g., by visually organizing the display; Nordfält 2011). Therefore, consumers' level of awareness can be increased by altering their beliefs about the environment (e.g., likelihood of finding deals) or by changing content in the environment—using creative packaging, violating norms, or lowering search cost (Janiszewski 1998; Xia 2010).

2.2 Screening

The screening stage typically involves a preliminary assessment of an alternative's prospective value. In consumer choice, screening yields either the disqualification of an alternative (or information) or its retention as useful for further processing. For example, the blue product may be highly salient on the shelf leading to its awareness. However, if the consumer's favorite brand is in a bright yellow box, once it has been seen, the blue product is processed no further. As shown in Fig. 1b, attention in service of screening activity is characterized by short, repeated, dispersed fixations on individual products.

Streicher et al. (2017) directly manipulate broad vs. narrow attention by priming people to consider an entire visual space or consider the central location of a visual space. They find that people primed for broad attention see more products. Mormann et al. (2015) show how bottom-up cues (i.e., colors, brightness of food packaging) and top-down cues (i.e., one's food preferences) influence awareness and screening so that products enter a consideration set.

2.2.1 Screening stage research opportunities

Future research should examine factors that can encourage screening. For example, there may be a valuable product feature that requires focused attention for understanding ("I need to make sure that the soup is low in sodium."); the screening information may be easy to attend (e.g., "Is this a decaf coffee? Yes, if there is an orange label." See Wastlund, Shams, and Otterbring 2018); and unexpected or novel features may encourage screening ("Beer made with 100% renewable energy. Is this something that I care about?").

2.3 Evaluation

Effortful evaluative processing occurs post-inclusion in a consideration set. It involves acquiring (whether via learning or recalling) the needed information, typically about the absolute and relative performance levels in attributes. This information is then used to make an informed judgment about an individual product or to compare it with other alternatives.

Because evaluation is influenced by so many factors, it is best studied with both attention trace and non-attention trace measures (such as verbal recalls). To illustrate, a scanpath of where a consumer is looking at the shelf may usually indicate systematic evaluation. However, it may also signal a distraction (e.g., a saccade to a distant empty location), confusion (e.g., random scanning), or the solidification of tentatively made choice (e.g., a hub-and-spokes pattern with the

tentative choice at the hub). A researcher can record fixations during choice and then use retrospective verbal protocol that is prompted by a video replay of consumers' fixations to aid the recall of their corresponding thoughts (Russo and Dosher 1983). The combination of the attention trace and the verbal report enables inferences about the decision-maker's strategies.

Evaluation stage subsumes two sets of processes: *within-alternative evaluation* and *between-alternative evaluation*. Within-alternative evaluation involves examining multiple features of the same option before considering the next option. As shown in Fig. 1c, within-alternative evaluation reflects compensatory decision strategies and is indicated by intra-brand saccades on complete attribute information (Pieters and Warlop 1999). Between-alternative evaluation is the process of comparing multiple products along the same attribute, as when people examine the price of all options to find the cheapest one. As shown in Fig. 1d, between-alternative evaluation reflects non-compensatory decision strategies and is indicated by inter-brand saccades on a limited set of attributes (Pieters and Warlop 1999).

2.3.1 Evaluation stage research opportunities

Future research should identify ways via which evaluation can be enhanced. First, attention can influence how a *representation* of the choice problem is constructed. For example, one may be able to use bottom-up factors to increase the likelihood that a specific representation is realized (e.g., a sequence of attention on price-brand-product claim might support a quality inference, but a sequence of attention on brand-product claim-price might support a brand differentiation inference). Similarly, the order in which information is presented matters: consumers give more weight to information presented first, partly because this information garners more attention (Willemsen et al. 2011).

Second, future research should examine factors that increase within-alternative consideration and those that shift the decision-making strategy from within-alternative to between-alternative evaluation. For example, an increase in the proximity of potential alternatives facilitates comparison (Russo and Rosen 1975; Wästlund et al. 2018); the presence of two or more unique options elicits comparison and motivates choice (Dhar and Nowlis 2004); the ease of perceiving options (i.e., fluency) encourages choice over deferral (Novemsky et al. 2007); and the easier it is to compare options, the more likely people are to make choice (Gourville and Soman 2005). Attention trace measures can confirm prior claims of a shift in choice strategy or show that some of these effects are attributable to other decision-making activities (e.g., choice execution).

Finally, in terms of methodology, another opportunity lies in combining various process trace measures. The combination of the attention trace and the verbal report enables inferences about the decision-maker's strategies (Russo and Dosher 1983). More recently, Meissner et al. (2019) discuss how combining eye-tracking with virtual reality settings can benefit research on shopper behavior (e.g., by integrating measurement of body position and movement). Future research should continue to combine different types of process measures to gain even deeper understanding of the decision-making process.

2.4 Choice execution

The execution, including the actual act of selecting an alternative and what happens immediately after that, is an oft-neglected topic. The act of terminating the evaluation and comparison processes is often assumed to be equivalent to the execution of a purchase. Yet, both online and in-store shopping studies suggest that consumers often abandon chosen items and fail to complete the purchase. In fact, the average online shopping cart abandonment rates are nearly 70%, and sometimes as high as 80% (Baymard Institute). Reasons for this behavior include using the shopping cart to achieve incidental goal-consistent behavior (shopping is "fun" and placing items in a cart achieves this goal), as an organization tool (i.e., a de facto consideration set), or as a holding stage (e.g., waiting to reduce uncertainty, waiting for more resources, resolving a size or quantity dilemma).

2.4.1 Choice execution research opportunities

To the extent that a consumer intends the shopping cart to be a holding stage, so that uncertainty can be reduced, it would be advantageous to have attention trace indicators of post-choice uncertainty. For example, post-choice uncertainty may be indicated by a consumer who continues to examine the product assortment after committing to an alternative by putting it in her shopping cart (Russo and Leclerc 1994). If sellers are able to recognize such behaviors by monitoring an attention trace, they may be able to identify an appropriate intervention. Two additional attention trace measures that could indicate uncertainty may be the number of alternatives considered and placed into the shopping basket, or the number of items considered and revisited within the shopping basket. Future research could examine whether placing more items into the basket increases the cumulative uncertainty of the basket. Placing more items into the basket could also lead to higher total cost of the purchase, which would further escalate levels of uncertainty

Since little is known about attention traces at this stage, we hypothesize one potential attention trace, as shown in Fig. 1e. Russo and Leclerc (1994) found that, after an extended fixation period on the selected alternative, some supermarket shoppers "scanned" about for other alternatives in order to ensure that they had made "the right decision." This scanning parallels the "awareness" stage where the consumer is trying to make sure that a better item was not overlooked. The final period of choice, including a checking process, has received relatively little study. As online shopping becomes more common, this part of the consumer decision process provides an important area for future research.

2.5 Summary

The current methodological and theoretical developments in attention research allow us to begin to identify and categorize the different attention-based process traces into a taxonomy useful to decision researchers. Once we have a better understanding of various "types" or "signatures" of attention, we may be able to ask, and answer, questions that cannot be addressed currently. We discuss one such area of research next.

3 Using attention trace measures to enhance computational models of choice

Attention traces can provide evidence to enhance or challenge traditional models of decision-making. In fact, decision researchers have begun developing richer computational models of choice that explicitly account for the role of attention. One class of such models is evidence accumulation models (for a comprehensive review of diffusion decision models see Ratcliff et al. 2016)[2]. These models posit that the more evidence a person accumulates for a particular alternative, the more likely this alternative is to surpass a cutoff for choice. However, they differ in the assumptions and conclusions they make about the role of attention.

Krajbich and Rangel (2010) assume that fixations during choice are stochastic and lead to an attentional bias, according to which the alternative being attended to accumulates more evidence (this is consistent with Decision Field Theory; Diederich 1997). Towal, Mormann, and Koch (2013) challenge the idea that consumers look at choice alternatives in a random fashion, and the first step of their two-step model of attention and choice relies on actual eye movements. This initial step uses insights from visual neuroscience, such as determining the weights of bottom-up and top-down cues in influencing which alternatives consumers look at and when they do so. The second step uses these probabilities of various "looking paths" to determine the likelihood that a given alternative will be chosen. Towel et al. suggest that bottom-up and top-down cues affect fixations and that, as a result, differing fixation patterns may affect the choice process. Others have begun exploring the idea that attention operates on the attribute level and that decision-makers compare all alternatives on the attribute that is being attended to (Bhatia 2013; Trueblood, Brown, and Heathcote 2014; Turner et al. 2018; Roe et al. 2001). These models are often able to predict the emergence of multiattribute context effects, such as those involving decoys and reference points. In general, by specifying not only where decision-makers look but also how attention interacts with preferences, these models capture the role of prior beliefs, primes, and various complex contextual factors on decision processes.

Of course, such models can also be parametrized and fit to human behavioral data, and can be compared with each other based on the accuracy of their predictions of these data. Recent work in this area has found that a multitude of different assumptions, taken from different competing models, are necessary to obtain the best fits to data (Turner et al. 2018). Highly complex models, reflecting these diverse assumptions, can now be built and simulated, in order to provide a nuanced computational account of consumer decision processes.

The ongoing effort to explicitly incorporate attention into models of choice creates opportunities for future research. First, while some models assume attention only influences information acquisition (Towal et al. 2013), other models assume attention has a causal effect on the valuation process (Krajbich and Rangel 2010). Future research can use the proposed attention trace measures to further address the causality claim. Second, the predictive ability of choice models is fundamental to their value.

[2] These models are built upon earlier models of perceptual decision-making, see Gold and Shadlen (2007) and Ratcliff and McKoon (2008). Due to space constraints, we focus only on accumulation models relevant to our discussion of attention.

Assessing attention traces for relevant decision variables (e.g., product attribute information, price information, promotion signals) should increase model accuracy (Bhatia 2017). Third, prior models of attention and choice rely on simplistic, two-alternative choice contexts (e.g., selecting between two highly familiar snack food items by pressing a keyboard button). Future models should focus on larger choice sets and representative response formats. Finally, models of attention and choice often fail to reflect natural choice environments. Industry leaders (e.g., Facebook, Disney, and Google) take advantage of the predictive power of real-time decision process data (e.g., body movement, mouse movements, clicks) to determine what content to display (Domingos 2015). Thus, combining decision process data and computational models (or machine learning) can provide insight into the information needed to instill choice confidence and encourage purchase (Ashby et al. 2016).

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