Display Complexity Affects Visual Processing of Horticultural Plant Retail Displays[1]

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Abstract

Attractive displays can stimulate sales in the retail setting. With most plants still sold in physical retail outlets, the influence of display layout on visual behavior and purchasing is of interest to academicians and practitioners. Using a within-subjects in-lab experiment and eye tracking technology, we explored how the cognitive load imposed by horticultural retail displays affects visual attention and choice. Display layouts were varied for six choice tasks in which participants indicated their most preferred alternative and their likelihood-to-purchase that alternative. Our study suggests that as the number of plant genera increases, perceived display complexity increases, and participants ignore a larger percentage of the products in the display while spending a lower percentage of their gaze sequence fixated on their choice product. Implications for retailers include increasing horizontal merchandising, reducing vertical merchandising, and diversifying the product mix in the display.

Index words: cognitive load, eye tracking, marketing, retail displays, complexity.

Species used in this study: *Buddleia davidii* Franch. 'Little Nugget', *Campanula portenschlagiana* Resholt (Roem. & Schult.), *Coreopsis grandiflora* L. 'Sunburst', *Echinacea purpurea* Moench 'Delicious Candy', *Hydrangea paniculata* L. 'Limelight', *Lupinus spp. L.* 'Tutti Fruitti', *Sempervivum* cv. L, *Spirea japonica* L. 'Double Play Red'.

Significance to the Horticulture Industry

With more than 70% of all buying selections made at the point of purchase (Ståhlberg and Malia 2007), firms participating in the study invested approximately $18 billion each year on in-store marketing (Nelson and Ellison 2005). As most live plants are sold in the retail environment and not online (Behe et al. 2008), a well-organized display in the retail setting can improve sales dramatically while poorly designed displays can have customers not even pausing for a glimpse. We investigated how increasing the number of genera in a display as well as horizontal versus vertical merchandising affected visual attention and product choice. Results suggest that with increased number of genera, display complexity increased, and participants ignored a larger percentage of the products likely because they could not "read" the display like lines in a book. To reduce the cognitive burden consumers may have in "reading" a display, retailers should merchandise plants horizontally, not vertically. Additionally, greater plant diversification increased the likelihood that a consumer would find a product they would like to purchase.

Introduction

Horticultural retailers have great flexibility in their display designs, but increasing the complexity also invites unintended consequences. Layout configurations must maintain a delicate balance of creativity and functionality to promote purchasing behavior, centering around consumers' visual attention and the cognitive burden imposed by the display. Indeed, tradeoffs exist in each display decision. For example, a retailer may simplify the choice setting and allow consumers to consider all purchasing options by presenting fewer alternatives in their display, but the lack of product variety may fail to capture the consumer's attention or preferences. Similarly, large displays can correct for the lack of variety, but they also increase search costs for consumers to find their optimal choice alternative.

This study explored how retail display layout can affect a consumer's decision-making process. Consumers often engage in heuristic-driven decision-making processes, and these, sometimes unplanned, purchasing decisions may be driven by a well-designed retail display. Thus, the objective of retail marketing is to enhance attention paid to the display, as the longer a consumer attends to a certain product, the more likely the consumer will choose to purchase that product (Behe et al. 2014, Grebitus et al. 2015, Gidlöf et al. 2017, Rihn et al. 2015, 2016).

Display layout mediates visual attention, cognitive recollection, and plant purchase behavior (Behe et al. 2015, 2018, Huddleston et al. 2018, Reutskaja et al. 2011). Horizontal displays are arranged in one linear plane parallel to the floor, where the consumer's eye is drawn from left to right (or right to left) and are thought to be more salient and cognitively appealing compared to vertical displays (Deng et al. 2016). Plant retailers commonly use this type of display layout as it facilitates plant maintenance, especially irrigation, while simultaneously making product available for purchase. By contrast, vertical displays have multiple, smaller linear planes arranged proximate to each other or perpendicular to the floor. In this display type, the consumer's eyes look from top to bottom (or bottom to top) and across shorter rows. Tiers create a series of horizontal planes which also permits plant maintenance but with a much narrower width,

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making more efficient use of vertical space. A component of display layout that has thus far been ignored is the ability of a consumer to cognitively process products in "flat" versus "tiered" displays or horizontal v. vertical merchandising.

Few studies have explored how differences between retail display layout might influence a consumer's choice for live plants as retail products. Generally, prior studies have focused instead on packaged merchandise where consumers decide between similar alternatives which may use branded packaging for processed foods and beverages in a retail setting (Grebitus and Roosen 2018, Reutskaja et al. 2011, Van Loo et al. 2015, Malone and Lusk 2017, 2018, 2019). Unlike packaged, processed goods, horticultural products are often minimally packaged, creating less distinctive features that may indicate quality to be considered by the consumer before purchasing. Furthermore, many are live products which require some care and maintenance *in situ* (e.g., irrigation and sunlight).

Even when choice alternatives are in the same plant genus, an individual plant might have some unique characteristic at the point of sale that influences a consumer's decision (e.g., number of flowers, plant turgor, blemishes or residue on leaves or flowers). Additionally, while some packaged food sales are shifting from in-store to online (Szahun and Dalton 2021), most horticulture products are still commonly purchased in person (Behe et al. 2008). Our study informs the design of horticultural displays, demonstrating that some layouts or complexity may be easier to cognitively process and thus promote purchases better than others.

In this study, we utilize eye tracking (ET) technology to explore the relationship between cognitive load and display layout. We tested for changes in cognitive load by manipulating the display layout and genera number, enabling us to determine how product layout influences a consumer's visual attention and decision-making.

Cognitive load and eye tracking. The cognitive load imposed on the individual is defined as the working memory resources required to complete a specific task (Sweller 1988, Drichoutis and Nayga 2020). Extrinsic cognitive load, one of the three branches of cognitive load, is the most relevant component of cognitive load for this study in that it refers to the choice layout surrounding a problem or decision. By coupling an experimental design with varied display complexity and tracking eye movement, we can identify a unique, objective measurement of extrinsic cognitive load through visual attention (vs. inattention), since vision is typically the main avenue for information input (see Huddleston et al. 2018 and Van Loo et al. 2018 for comprehensive reviews of eye tracking use in retail studies). By tracking participant attention from the moment an experiment starts to the final choice, researchers can quantify various measurements of visual attention such as time to choice (TTC) and metrics for specific areas of interest (AOIs), including total fixation duration (TFD) (i.e., how long the participant fixates on an AOI), and time to first fixation (TTFF) (i.e., how long it takes for the participant to fixate on an AOI). ET removes post-hoc reliance on consumer recall and reduces concerns about desirability bias, as asking respondents to recall information after each round of an experiment can lead to inadequate or inaccurate responses (Graham et al. 2012). ET serves as a proxy for display interaction by providing useful measurements of cognitive load such as TFD and TTFF based on participant visual attention without relying on a subject's working memory.

Only one prior study investigated the influence of display structure on cognitive load and visual non-attendance (VNA). Staples et al. (2022) showed that in horizontal displays of homogeneous 6, 12, and 24 plants, VNA increased as the number of plants in the display increased. As the number of plants in the display increased, the percentage of time spent on the chosen product declined precipitously. Furthermore, there were specific areas—especially the front display corners—that suffered from the greatest VNA. Even though horizontal or flat displays predominate the horticultural retail setting, could a change in display layout and the number of plant genera in the display influence the visual dynamics and ultimately purchase?

We hypothesize that changes in display layout will lead to varying levels of cognitive load. Once a product display becomes too sizeable and burdensome, consumers will ignore a large share of the alternatives and will exhibit common patterns of VNA. Instead of attempting to equally view all alternatives in the display, consumers will engage in common visual attention patterns where disproportionate levels of attention will be given to the top-middle of the displays. Second, we hypothesize that when product displays increase in complexity or incorporate multiple genera in varying layout orientations, consumers will take longer to make their decision and engage in common choice tasks.

Materials and Methods

To test the hypotheses, we recruited participants to an in-lab campus study through an online survey database maintained on campus. Respondents were provided with an approved informed consent form (Exempt Category 98, Study #0458), then fitted with Tobii 2 Pro (Danderyd, Sweden) ET glasses using a single-point calibration. We employed wearable ET technology, as it provided more realistic experimentation in a retail setting (Fenko et al. 2018). Participants' gaze was recorded using Tobii Pro Lab Software (Danderyd, Sweden) for data aggregation, mapping, and coding. Participants were shown two sample displays using candy bars to familiarize them with the task at hand and asked to select the product they most preferred from each display with a pointer to indicate choice and verbally indicate their likelihood to buy (LTB) on an 11-point Juster scale (Brennan and Esslemont 1994), which was posted at each display as a reminder.

We constructed three displays with live herbaceous perennials and (separately) three displays with live woody shrubs. The least complex design had one genus, where the single-genus perennial display included 12 *Coreopsis grandiflora* 'Sunburst' (4 per tier) and the single-genus shrub display held six *Hydrangea paniculata* 'Limelight' per tier for a total of 18 plants. The more complex display

Table 1. **Display identification characteristics including the number of plants included in the display, the genera placement (homogeneous, vertical, horizontal), a perennial or shrub display indicator, the genera included in the display, and the plant price (n=97 participants).**

Display ID	# of Plants	Genera placement	Perennial or shrub	Genus species cultivar	Flower color	Price
12H1P	12	Horizontal	Perennial	*Coreopsis grandiflora* 'Sunburst'	Yellow	$5.99
18V2P	18	Vertical	Perennial	*Campanula portenschlagiana* Resholt	Blue	$5.99
				Echinacea purpurea 'Delicious Candy'		
18H3P	18	Horizontal	Perennial	*Echinacea purpurea* 'Delicious Candy'	Pink	$5.99
				Sempervivum cv.	Pink	
				Lupinus 'Tutti Fruitti'	Purple	
18H1S	18	Horizontal	Shrub	*Hydrangea paniculata* 'Limelight'	No flower	$19.99
18V2S	18	Vertical	Shrub	*Buddleia davidii* 'Little Nugget'	No flower	$19.99
				Hydrangea paniculata 'Limelight'	No flower	
18H3S	18	Horizontal	Shrub	*Buddleia davidii* 'Little Nugget'	No flower	$19.99
				Hydrangea paniculata 'Limelight'	No flower	
				Spirea japonica 'Double Play Red'	No flower	

designs included either two or three genera. These stimuli all contained 18 plants each with genus placement appearing vertically for the two-genera displays or horizontally for the three-genera, creating plausible displays a shopper might see in the retail environment (Table 1 summarizes the characteristics of the displays. Figure 1 presents the displays utilized on the first day of the experiment). Each display included an informational sign centrally placed on the middle shelf with the price and plant common name. Consistent with Midwestern market rates, plants were priced at $5.99 per plant for perennials and $19.99 per plant for shrubs. The three-genera perennial displays were rotated by tier daily, while the two-genera perennial display was rotated by side after the second day of data collection. The remaining displays—the single-genus perennial and all shrub stimuli (plants)—remained in the same position for all four days of the experiment.

Displays were constructed in a university classroom and assigned a random position in the classroom among six stations. Displays were constructed with black cloth surrounding each display, so the display was only visible to the subject when standing immediately in front of it. Participants walked through the study in a manner so no other displays were visible prior to arriving in front of each display. Participants walked in a counterclockwise sequence to view displays, with each successive participant beginning the study at the next display in the sequence. Study room lighting was by standard overhead fluorescent light fixtures. Upon conclusion of the choice tasks, participants responded to a questionnaire indicating resource allocation, gardening behavior, plant expertise, and demographic information.

Data analysis. Data were aggregated by mapping each subject's gaze onto the display images using the Tobii Pro

Fig. 1. Displays photographed on day 1 of three day in lab study. Display identification number shows number of plants (12 or 18), display layout (H=horizontal, V=vertical), number of genera (1, 2, 3), and whether the display is comprised of perennials (P) or shrubs (S).

Fig. 2. Example display with eye tracking areas of interest (Display 12H1P: 12 plants, horizontally merchandised with 1 perennial genus.)

Lab Real-World Mapping tool, followed by manual corrections and event coding. The TTC variable in the gaze data was designated as the time between the subject's first fixation on a plant in a display to an indication of purchase intent, either a buy or no-buy decision.

We took digital images of displays and digitally identified the AOIs in each display, including the areas occupied by each plant, the informational sign, and the rating scale sign. Figure 2 shows the eye tracking AOIs for the 12-plant display in the experiment. Any fixation captured within the outline of a given AOI counted towards the fixation count and time devoted to that AOI.

We next extracted visual metrics for each participant: TFD and TTFF for each AOI which were drawn around each plant and the price sign. Specifically, we were interested in the TFD and TTFF for each plant alternative in each display. AOIs with a TFD equal to zero indicated that the individual never visually attended to the corresponding AOI. This allowed us to compute the percentage of visual nonattendance (VNA) in each of the displays. Given the size of the display (either 12 or 18), we took the number of plant AOIs with a TFD equal to zero and divided it by the number of alternatives in the display (and subsequently multiplied by 100 for a percentage).

After computing VNA for each respondent and each display, we turned our attention to choice and the various metrics surrounding it. The TTC measured the entire gaze sequence from first fixation on the display to verbal selection of final choice plant. We then matched participant choice (e.g., AOI Plant A) with the TFD devoted to that AOI (e.g., TFD for AOI Plant A), facilitating the measure of TFD devoted to choice. For example, if individual *i* selected alternative *a* in display *j,* we took individual *i's* TFD on plant *a* in display *j*. From this measure, we generated the proportion of a participant's gaze sequence devoted to their choice by dividing the TFD devoted to choice by the TTC. This new measure allowed us to account for, or standardize, the notion that average TTC increased as the display size increased, thus we would expect TFD to increase as well. We were interested in how the proportion of a gaze sequence devoted to choice changed based on the display layout and genera number. This measure facilitated this investigation. Similarly, we computed the measure of TTFF for choice, identifying the total time duration it took for respondents to fixate on their eventual choice. If the eventual choice was the first fixation, then TTFF was zero.

We utilized four eye tracking metrics for cognitive load. We first explored measures of VNA, which we defined as alternatives that were never attended to visually. Because visual attention is required for cognitive processing (Huddleston et al. 2018), we inferred that if respondents never visually attended to an alternative, they did not cognitively process it. In other words, if they did not see it, they could not buy it. Second, we investigated TTC and gaze length, measuring how long participants visually engaged with the display before deciding which plant to buy (or no choice). Finally, we considered TFD and TTFF to determine how visual attention influenced choice. All data and stimuli can be found in the online OSF repository: https://osf.io/2kmg6/?view_only=1c030f082be947459633abc02ee776ae.

Results and Discussion

Data for the experiment were collected over four days in May 2018, with 97 individuals participating: n = 26, 25, 25 and 21. Each participant was compensated $20 for their participation. In total, 581 observations were included for analysis; one observation for display 18V2P was dropped due to poor quality.

Sample characteristics. Participants were 28.9% male and 71.1% female with a mean age of 30.2 years (s.e.=1.0). Nearly half (40.2%) had completed a four-year college degree with 23.1% having less education and 36.7% having more education. The sample was predominately Caucasian (57.7%) with Asian (17.5%), African-American (9.3%) and other ethnic heritages (15.5%) comprising the remainder of the sample. Median household income fell into the category of $60,000 to $79,999. Purchases of plants were made by a majority of the sample, including herbs (purchased by 65.0% of the sample), vegetables (46.4%), indoor plants (43.3%), flowering annuals (38.1%), flowering perennials (25.8%), flowering shrubs (20.6%), and other plants (23.9%) spending an average of $79.50 (s.e.=$9.63) on plants in the three months prior to the study. Thus, the sample was representative of plant purchasers in the Midwest.

Visual non-attendance. The average VNA for the 18 plant displays ranged from 9.97% to 19.97% (Table 2), indicating plant number was not the only signal of VNA, in contrast to Staples et al. (2021). The lowest VNA was for the three genera perennial display merchandized in a horizontal layout where each tier contained a different plant genus. One potential explanation for the low VNA is that horizontal marketing is easier for participants to visually process. Indeed, the display with the greatest VNA (19.97%) was the two genera perennial display using vertical merchandising (side-by side placement). The large and statistically significant difference between VNA levels

Table 2. **Mean visual non-attendance (VNA) or the percent of all plants ignored, the position of plant with greatest VNA percentage in each display (n=97 participants), and the percentage of the gaze sequence devoted to each shelf[z]. Display identification number shows number of plants (12 or 18), display layout (H=horizontal, V=vertical), number of genera (1, 2, 3), and whether the display is comprised of perennials (P) or shrubs (S).**

			Mean % of gaze sequence devoted to each shelf	
Display	Mean % VNA	Position with greatest % VNA	Shelf	% Gaze sequence
12H1P	5.76%	top-left corner (12.37%)	Top	28.35%
			Middle	17.01%
			Bottom	28.98%
18V2P	19.97%	bottom-left corner (42.71%)	Top	14.58%
			Middle	31.10%
			Bottom	27.37%
18H3P	9.97%	bottom-right corner (26.8%)	Top	23.53%
			Middle	27.51%
			Bottom	22.77%
18H1S	13.29%	bottom-right corner (30.93%)	Top	28.69%
			Middle	26.32%
			Bottom	20.68%
18V2S	18.21%	bottom-right corner (50.52%)	Top	20.50%
			Middle	28.90%
			Bottom	23.67%
18H3S	14.43%	bottom-right corner (30.06%)	Top	35.28%
			Middle	19.13%
			Bottom	17.34%

[z]Note: The mean percentage of a respondent's gaze sequence devoted to each shelf was calculated by summing the total fixation duration for all AOIs on the corresponding shelf and dividing by the time to choice. The proportion of the gaze sequence devoted to the three shelves sums to less than one because of the respondent's time devoted to the price sign and disengaging with the display (i.e., not looking at any of the display's AOIs).

Note: Display 18V2P had 96 observations due to data limitations for one respondent.

supports the argument that vertical marketing is more cognitively taxing than horizontal marketing (Deng et al., 2016). We saw a similar trend for the two- and three-genera shrub displays, but the difference in means was not significant at the 10% level.

The plant with the greatest VNA was a corner in all six displays (Table 2), with the bottom-right corner ignored to the greatest extent (50.2%) for the two-genera shrub display (18V2S). Across all six displays, the three AOI locations with the highest VNA rates were in the corners or outer edge of the displays (Table 3), signaling that consumers' visual attention gravitated towards the center of the display. Indeed, while plants were not merchandised to the ground level, it was the center of the top and middle shelves that often had the lowest VNA rates. This finding is consistent with Atalay et al. (2012), which showed that visual attention moved to the brand located centrally in a horizontal array of movie titles and energy drinks, both of which were located on only one shelf. This finding expands their Central Gaze Theorem to include multiple shelves with both horizontal and vertical merchandising.

Furthermore, the average TFD did not differ by shelf (average gaze time on each shelf top: 25.16%, middle: 24.99%, bottom 23.47%). Thus, placement of higher quality plants on a higher shelf may not produce the intended effect of a perception of higher quality. In the fast-moving consumer-goods (FMCG) arena, shelves at eye-level are more likely to be seen by consumers and thus command higher prices (known as slotting fees) from retailers to have the product merchandised there (Chiakpo n.d.). Results here are contrary to this and would indicate that consumers are paying more visual attention to shelves that are not necessarily at eye-level in order to make their product selection. Coupling our findings with the existing retail and marketing literature suggesting that product placement affects visual attention, and ultimately choice (Chandon et al. 2009), our insights on VNA have significant implications for retail display layout.

Time-to-choice, opt-outs, and likelihood-to-buy. More complex displays—either through increasing the number of purchasing alternatives or introducing multiple genera within a display—could potentially impose a greater cognitive load on the consumer, leading to increased TTC. However, more visually appealing displays—using tiered layouts and employing horizontal marketing—could increase TTC for the average consumer without imposing a higher cognitive burden as the lower cognitive burden imposed by a more functional product display invites consumers to accept the higher search costs to find an optimal alternative. Retailers may want to utilize tiered displays with horizontal merchandising to capitalize on consumers' "reading" displays and ease of processing horizontally and increase to a modest extent, a limited number of products, perhaps 2-3, that might be effectively cross merchandised with the plants. These may be other plants, containers, or fertilizers. Horizontal striping would facilitate visual processing while limiting the number of additional products could increase purchase alternatives without substantially increasing cognitive load.

The literature on choice overload suggests that complex choice settings invite unintended consequences, where consumers may become less confident in their choice (Haynes 2009), regret their choice decision (Inbar et al. 2011), or refrain from entering the market entirely (Berger et al. 2007). As such, it is plausible to suspect that individuals who experience cognitive overload from the choice settings to opt-out more frequently or have a lower LTB.

The three-genera shrub display with 18 plants merchandised horizontally (18H3S) had the highest "no choice" or opt-out rate at 10.3% (10 participants), followed by the two-genera shrub display (18V2S) at 9.3% and the one-genus perennial display (12H1P) at 7.2% (Table 4). Only 1% of respondents opted-out of the two- and three-genera perennial displays, and these had the highest average LTB at 7.32 and 7.65, respectively. Because the experiment used different perennial plants and shrubs, lower opt-out rates and higher LTB to display layout could be driven by plant type or introducing variety in the display (i.e., multiple genera).

Display opt-our rates could also be driven by consumer heuristics related to visual attention and cognitive processing. As the display complexity increases, the consumer

Table 3. **Percentage of respondents (n=97) that never visually fixated on each area of interest (AOI) for each display[z]. Display identification number shows number of plants (12 or 18), display layout (H=horizontal, V=vertical), number of genera (1, 2, 3), and whether the display is comprised of perennials (P) or shrubs (S).**

12-plant display AOIs

A	B	C	D
E	F	G	H
I	J	K	L

18-plant display AOIs

A	B	C	D	E	F
G	H	I	J	K	L
M	N	O	P	Q	R

Perennial displays

12H1P

12.4%	1.0%	3.1%	7.2%
6.2%	1.0%	4.1%	6.2%
11.3%	6.2%	3.1%	7.2%

18V2P

18.8%	6.3%	20.8%	22.9%	19.8%	30.2%
35.4%	9.4%	5.2%	7.3%	6.3%	21.9%
42.7%	14.4%	8.2%	8.2%	7.2%	26.8%

18H3P

3.1%	8.2%	4.1%	9.3%	10.3%	18.6%
10.3%	3.1%	2.1%	5.2%	5.2%	16.5%
19.6%	14.4%	8.2%	8.2%	7.2%	26.8%

Shrub display

18H1S

26.8%	8.2%	0.0%	5.2%	8.2%	16.5%
19.6%	6.2%	2.1%	5.2%	8.2%	24.7%
8.2%	14.4%	17.5%	16.5%	20.6%	30.9%

18V2S

28.9%	11.3%	9.2%	9.3%	16.5%	22.7%
23.7%	12.4%	1.0%	3.1%	11.4%	26.8%
29.9%	15.5%	9.3%	20.6%	26.8%	50.5%

18H3S

8.2%	5.2%	3.1%	7.2%	10.3%	12.4%
26.8%	13.4%	3.9%	2.1%	5.2%	25.8%
29.9%	15.5%	14.4%	23.7%	17.5%	36.1%

[z]Shading indicates the three AOI positions with the highest non-attendance rates.

Note: Display 18V2P had 96 observations due to data limitations for one respondent.

could consciously or subconsciously choose to devote attention to fewer alternatives in the display. In doing so, they simplify their choice setting and may devote a larger share of their gaze sequence to the alternative that they eventually select. Staples et al. (2021) show how average VNA rates increase as the number of plants included in this display increase, and we see here that including multiple genera and using different merchandizing strategies can influence VNA rates. Thus, it is necessary to explore how time devoted to a given AOI affects choice and whether the time devoted to the selected alternative varies based on the complexity of the display.

Time devoted to choice and time to first fixation. Study participants, on average, chose the alternative that they fixated on the longest, a finding that coincides with much of the literature on visual attention and choice (Behe et al. 2015, Gidlöf et al. 2017, Reutskaja et al. 2011). Of the 547 observations (of 581) where a plant was selected, 81% of respondents (449 observations) fixated the longest on the alternative they eventually selected (Table 5). Moreover, participants tended to fixate on their selected alternative rather quickly, averaging their first fixation on the selected alternative within the first 25% of their gaze sequence, or, in this study, in approximately 4.6 seconds. However, we do see that as display complexity increases, it took longer for participants to have their first fixation on their selected alternative. For instance, it took an average of 7 seconds for respondents to have their first fixation on

Table 4. **Summary statistics by display ID showing time to choice (TTC), number of "no choice" selections, and mean likelihood to buy across all choices (n=97 participants). Display identification number shows number of plants (12 or 18), display layout (H=horizontal, V=vertical), number of genera (1, 2, 3), and whether the display is comprised of perennials (P) or shrubs (S).**

Display ID	Mean TTC (in seconds) (std. dev.)	Number of "no choice" (% "no-choice")	Mean LTB: 1-10 excluding "no choice" (std. dev.)
12H1P	17.62 (10.61)	8 (8.24%)	5.96 (2.22)
18V2P[z]	16.36 (11.98)	1 (1.04%)	7.26 (1.70)
18H3P	20.80 (14.07)	1 (1.03%)	7.65 (1.74)
18H1S	19.83 (13.75)	6 (6.19%)	5.87 (2.15)
18V2S	18.50 (11.98)	9 (9.28%)	6.30 (2.11)
18H3S	20.49 (13.69)	10 (10.31%)	5.97 (2.13)

[z]Note: Display 18V2P had 96 observations due to data limitations for one respondent.

their choice alternative in the vertically merchandized, two genera, shrub display (18V2S).

The TTFF and TTC findings support much of the literature suggesting visual attention is a leading driver of purchasing behavior. The average consumer fixated the longest on the option selected, suggesting that visual attention is indeed an important indicator of purchasing behavior. Coupling this finding with the increased rates of VNA as display complexity increases suggests that for complex displays, a consumer may make a sub-optimal choice given that they are not considering all choice alternatives. However, the similar opt-out rates and LTB in this experiment suggest some ambiguity in this argument.

Even in the absence of time constraints, we saw consumers ignore a non-trivial share of the product displays; up to 20% for a vertically merchandised display. Indeed, this suggests that consumers sometimes cope with challenging choice scenarios by not looking at all the options. We demonstrated that as display complexity increases, so too does VNA. Furthermore, while visual attention is a leading indicator of choice, the percentage of a respondent's gaze sequence devoted to choice decreases as display complexity increases. However, participants' LTB was not strongly impacted by the increased display size and complexity despite higher rates of VNA and less time devoted to the choice product. In other words, they quickly found the desired product without examining all alternatives. Further, increased complexity led to heightened LTB on some occasions (e.g., display 18V2S versus display 18H1S).

Consumers can devote 31% to 40% of their product selection time looking away from the product set to assist in cognitive processing of information before deciding (Behe et al. 2020). Our results are consistent with participants' desire (if not need) to disengage from stimulus input to make a choice; they also support the notion that eye tracking measurements can be used as a sole indicator to predict choice (Chavez et al. 2018), where the most visually attended to alternative is chosen between 70 and 91% of the time.

ET technology enables us to explore the relationships between display complexity, visual attention, and choice. However, one shortcoming from using ET metrics is that visual attention does not imply cognitive processing. We capture participants' fixations on AOIs through the ET technology, but a positive fixation count on an AOI does not imply the participant could recall and may not necessarily indicate that the participant can recall visually attending to the alternative. In other words, the ET glasses are so light and comfortable, participants may forget they are wearing them. Furthermore, the technology is so accurate that participants may not remember they looked at a specific plant but the technology can track it. Nonetheless, our measurement of VNA serves as a lower-bound estimate of the percentage of the display a consumer ignores, as the share of the display a consumer does not cognitively process is at least as large as the VNA tracked by the ET software.

The other central limitation to our experiment is the possibility of hypothetical bias. While a binding experiment in which participants purchased their selected alternative would alleviate this concern, we believe that the non-binding nature of our horticulture study was a necessary condition to avoid introducing bias into the experimental design. That is, if participant *i* purchased plant *x*, then this plant would need to be replaced and thus it would bias the experimental design. Unlike processed food products with standardized labeling across identical alternatives, horticulture alternatives of the same genus are subject to heterogeneous product characteristics.

Table 5. **Summary statistics for choice by display ID for mean time to choice (TTC), mean time to first fixation (TTFF) of choice plant, mean percent of gaze devoted to choice plant, and the percentage odds that the plant with the greatest TFD was the chosen plant[z]. Display identification number shows number of plants (12 or 18), display layout (H=horizontal, V=vertical), number of genera (1, 2, 3), and whether the display is comprised of perennials (P) or shrubs (S).**

Display ID	# of observations	Mean TTC in seconds (std. dev.)	Mean TTFF for choice in seconds (std. dev.)	Mean percent of gaze sequence devoted to choice	How often was the alternative looked at the most chosen?
12H1P	89	17.71 (9.97)	3.14 (3.29)	23.23%	87.64%
18V2P	95	16.48 (10.74)	3.13 (3.37)	20.33%	76.84%
18H3P	96	20.99 (14.02)	4.22 (5.37)	18.86%	75.00%
18H1S	91	20.34 (13.99)	4.38 (4.17)	20.43%	90.11%
18V2S	88	18.61 (12.10)	7.02 (5.96)	19.19%	78.41%
18H3S	87	21.22 (13.89)	6.20 (6.14)	19.43%	86.21%
Mean	**546**	**19.22 (12.63)**	**4.65 (5.04)**	**20.20%**	**82.08%**

[z]Note: Participants who made "no choice" from the corresponding display were excluded from this analysis.

Future research might collect subjective measurements of cognitive load directly after each choice task to provide an avenue to better understand the role of working memory on the assessment of retail displays and help marketers mitigate adverse consequences from consumer heuristics in decision making. Future studies may also include other minimally packaged products (e.g., fresh produce) and inclusion of branded products as part of a choice heuristic would also be an interesting dimension for studying VNA.

Despite these shortcomings, this study has important implications for horticulture retailers where the tendency may be to develop complex displays. Display layout can mediate VNA and choice, where tiered displays may be more visually appealing to the consumer than flat displays, and horizontal marketing is a more visually appealing layout than vertical marketing, a finding that matches Deng et al. (2016). Display fixtures for vertical merchandising may carry added expense, but the investment may provide a fair return to create some visual difference from horizontal displays. Horizontal displays may have a greater labor expense to keep them stocked. More frequent merchandise stocking of perishable products may also reduce merchandise wear and tear (loss of foliage, for example), thus minimizing loss.

Practically, retailers will benefit by examining how their display layout reduces or increases the cognitive burden of their consumers. Vertical tiers are a practical strategy for merchandising horticultural products, offering shoppers easier visual processing compared to flat displays, particularly if the steps utilize horizontal marketing techniques.

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