The Sales Effects of Parts of Packages

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In March of this year, a team at the University of Edinburgh published a paper on the changes in people's brain activity as they strolled through town. Participants in the experiment wore a Bluetooth-enabled EEG device (electroencephalography) that monitored their levels of excitement, frustration, and meditativeness, among other emotions. They walked through a shopping district, a green space, and a commercial center. Not unexpectedly, the team found that participants were most at peace while strolling through the green space.

What interests us about this study, and what we seek to extend profoundly, is the granularity of the methodology. One might ask, "Exactly what about the green space was most peaceful?" More refined measurements would be needed to answer this question. If it turned out to be "the fountain," one might ask, "Exactly what about the fountain was most peaceful?" Still more refined measurements might show it was “the sculpture.” And so on. Increasing the measurement precision as we describe in this paper may well reveal results with profoundly different implications. It would be a very different matter if participants became peaceful while attending to the artistry of the sculpture versus, say, the streams of water in the fountain or the leaves on the trees beside the path.

Human attention, measured most simply with eye gaze, is redirected in milliseconds. And the brain's affective response occurs almost as quickly. Thus any research correlating attention with emotionality will need to get faster to approach neurological time. And as the measurement technology improves, so must the analytical technology. It was a simple matter for the Edinburgh team to match the stroller's EEG measurements with his or her presence in a green space during a 25-minute walk; but advanced technical and analytical technology will be needed to correlate <50 millisecond epochs in attention and biometric response. This is the contribution we wish to describe in this paper.

Motivating our innovation is the information needs of a variety of practitioners. A considerable industry has emerged around product packaging, which is a form of marketing in which small areas of interest are designed with great care and cost to capture attention and produce both affective responses and buying behaviors. To date, this industry has only been able to correlate affective responses to gross areas of a package, say the front, side, or back. Researchers simply haven't known what shoppers are looking at when their liking for a product is triggered. Too often, mere conjecture has been the ultimate answer to the most important questions about which element (say, a redesigned logo or the image of an Olympic athlete) produced the connection and the sale.

This paper introduces a new patent-pending contribution called BioNimbus. It is not a new EEG or eye tracking device, but instead a **software solution to synchronize millisecond sensations and reactions for analysis, which may take in either physical or virtual environments**. BioNimbus is agnostic to attentional inputs and biometric or behavioral outputs. We are currently optimized to assess the input of eye gaze dwells on precise areas of interest and synchronize these with electroencephalographic (EEG) or electrodermal (EDA) measures of emotionality. Although a great deal can be learned from this application, we anticipate there will be demand for analysis of other inputs (e.g., spoken instructions, animated or video-based messaging) and outputs (pulse, perspiration, micro changes in muscle tension or temperature).

Beyond product packaging, we see applications in security-related decision making. Police and security officials are increasingly called upon to scan crowds for behavior that might predict and ultimately prevent criminal acts. This takes place daily in airport security screenings, and sadly also at the finish line of this year’s Boston Marathon. We need to better understand this as a cognitive task involving attention and decision-making. What about the crowd attracts the attention of security officials? What elements of individuals arouse suspicion? Do officials react to elements that predict wrongful intentions, or are they distracted by elements that don't? We believe that valid answers to these questions will be found only

by segmenting continuous measures of attention and cognition down to millisecond epochs for synchronization, as BioNimbus is able to do.

Not an easy task

Although our work yields direct and parsimonious research findings (e.g., "in the milliseconds that participants looked at the Olympic athlete on the package, their electrodermal excitement increased, which in turn predicted sales") it is by no means simple to produce them.

There are currently devices that can present a moment-by-moment readout of attention and physiology, but to our knowledge only BioNimbus synchronizes these datastreams and appends them to the specific areas-of-Interest (AOI's) in such a way that they may be statistically correlated with outcomes.

In brief, the main technological requirements are as follows:

- **Dramatically increased granularity to very brief intervals.** To date, any attempt to correlate attention and emotion has done so only at very long intervals, from a 25-minute walk down to at best a 30-second television advertisement.

  Below, we report how BioNimbus correlates 33 millisecond epochs. Intervals this brief are essential for the validity of such correlations since attention may be shifted so rapidly. At any longer intervals, researchers can only guess what stimulated participants to react.

- **Confirmation of attentional focus.** At long intervals, researchers were forced to guess what participants were attending to at the moment they reacted. Even at intervals of a second or less, additional confirmation is need to know exactly what people are looking at.

  BioNimbus confirms what is stimulating participants with a bitmap texture on a moving 3D model in a virtual simulation. By confirming the xyz coordinates of optical focus, BioNimbus in turn decodes the specific AOI to which participants were attending.

  It's important to accurately decode the AOI because the AOI is really the index: it's the mark in the dataset that's held constant across the two datastreams -- that is, the attentional input (e.g., eye gaze dwelling on the image of an athlete) and the biometric output (e.g., electroencephalic, electrodermal, electrocardial).

- **Forcing the two signal streams to synchronize.** Brainwave data typically use one epoch, eye tracking data another, skin perspiration data yet another, and there are dozens of variations among hardware manufacturers. All of these data streams may employ different intervals, be it 20, 50, 100 or 1000 samples per second.

  To analytically append the inputs and outputs to AOI's, which is essential to determine whether they are truly correlated, they must be recorded during the same interval when the AOI stimulates the participant. BioNimbus accomplishes this synchronization.

Proof of concept

As a proof of concept, we undertook a study of 20 research subjects in December 2012 in Seattle under the observation of media-psychology researchers from the University of Washington.

We chose to conduct this experiment using cereal boxes on virtual supermarket shelves because of their clarity and face value. But the basic principles of attentional focus, biometric reactions, and behavioral decisions would apply equally to, say, law enforcement or security officer training.

Procedures and research questions

Participants were 25-54 year-old adults with children aged 2-17, and who regularly shop for cereal for their household. We sought a reasonable mix of males and female – roughly 60/40.

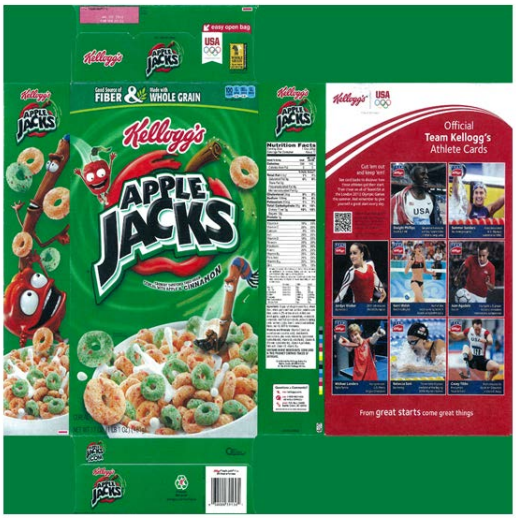
Participants were seated in front of a 24" computer monitor that presented a virtual reality simulation of a supermarket aisle. Each participant was fitted with a brainwave headset and an EDA bracelet. The latter is a device that detects changes in electrodermal activity on the wrist and sends these data via Bluetooth to the computer.

Each participant was trained in “how to shop” meaning they were shown how to use a Razer Hydra (resembling a nun chuck controller for a game console) to pull cereal boxes from virtual shelves and turn them to view top, bottom, back, and sides, as they would when physically in a supermarket.

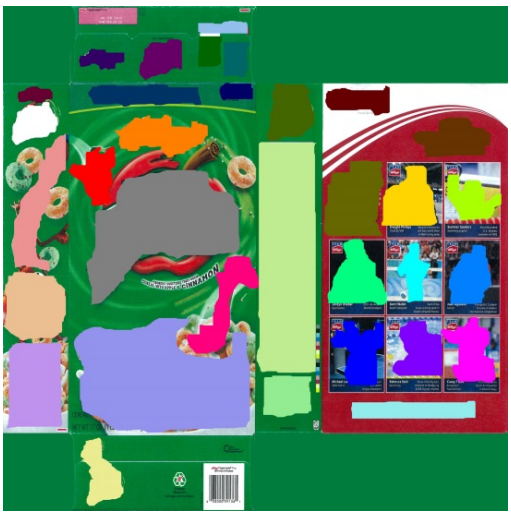
To make a purchase, participants were shown how to put items “in their basket” by touching the right button on the Razer Hydra. This buying action is what gives us the outcome variable for the correlations, and is important to note that it behavioral rather than self-reported. After training, each participant was asked to shop as they normally would, examining packages and buying whatever they wished.

Of the 28 cereal packages on the virtual shelf, we constructed 3D models for 2 (Apple Jacks and Frosted Flakes) which were running a promotion related to the Olympic games and celebrated athletes. The 3D models of these packages were coded with 25 granular AOI’s as shown in Figure 1.

Figure 1: Cereal box with marked Areas of Interest



AOI	Description
1	Apple character on front
2	Kellogg's logo on front
3	Athlete1
4	Athlete2
5	Athlete3
6	Athlete4
7	Athlete5
8	Athlete6
9	Athlete7
10	Athlete8
11	Cinnamon character on front
12	Apple Jacks logo on front
13	Kellogg's-Olympics text on back
14	Official Team Kellogg's Athlete Cards
15	Cut' em out and keep 'em text on back
16	Kellogg's-Apple Jacks logo on right side
17	USA Olympics logo on top
18	Whole Grain seal on top
19	Fiber and Whole Grain text on front
20	Calorie info on front
21	Kellogg's logo on top
22	Apple Jacks logo on top
23	Kellogg's logo on left side
24	Apple Jacks logo on left side
25	Cinnamon character on left side



The straightforward research question that BioNimbus allowed us to test with its granularity and synchronization was “Does attending to the Olympic athletes in a special promotion predict positive reactions and sales better than attending to typical elements like the logo, product picture, cartoon characters, or ingredients?” The answer to this question has clear business value: if the special promotion does not predict an elevated reaction or increased purchase likelihood, then it may not give a sufficient return on investment.

Metrics

Data from the BioNimbus system come back to us as event-related: the discrete interactions that participants have with the packages have a beginning and an end. An example is shown in Figure 2. This is a dwell event wherein Jordan, a male participant, brought the Apple Jacks package forward for a closer look. During this 790-millisecond period of time, he focused on AOI 2, which happens to be the brand logo on the front of the package. The 790-millisecond event is subdivided into roughly equal intervals of about 33 milliseconds each.

Columns 5-9 record his brain (EEG) states during these intervals and Column 10 records his electrodermal activity level (EDA).

Figure 2: Sample Event Data

1	2	3	4	5	6	7	8	9	10	11	12
participant	itemviewed	stocknumber	action	excitement	meditation	frustration	boredom	long-term-excitement	EDA	msTimestamp	msDelta
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	Dwell Start							131115	19
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7990714	0.3814366	0.8382538	0.695254	0.7996036	2.439	131129	14
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7990714	0.3814366	0.8382538	0.695254	0.7996036	2.422	131163	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7990714	0.3814366	0.8382538	0.695254	0.7996036	2.439	131197	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7990714	0.3814366	0.8382538	0.695254	0.7996036	2.433	131230	33
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7514963	0.3943206	0.8380695	0.7415344	0.7989033	2.439	131264	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7514963	0.3943206	0.8380695	0.7415344	0.7989033	2.435	131298	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7514963	0.3943206	0.8380695	0.7415344	0.7989033	2.423	131331	33
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7514963	0.3943206	0.8380695	0.7415344	0.7989033	2.428	131365	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.7514963	0.3943206	0.8380695	0.7415344	0.7989033	2.439	131400	35
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6163678	0.4059026	0.8379036	0.7757906	0.7958528	2.428	131432	32
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6163678	0.4059026	0.8379036	0.7757906	0.7958528	2.419	131467	35
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6163678	0.4059026	0.8379036	0.7757906	0.7958528	2.428	131500	33
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6163678	0.4059026	0.8379036	0.7757906	0.7958528	2.423	131534	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6096299	0.418651	0.8377543	0.8014562	0.7926196	2.428	131567	33
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6096299	0.418651	0.8377543	0.8014562	0.7926196	2.419	131601	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6096299	0.418651	0.8377543	0.8014562	0.7926196	2.423	131635	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6096299	0.418651	0.8377543	0.8014562	0.7926196	2.428	131668	33
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.6096299	0.418651	0.8377543	0.8014562	0.7926196	2.419	131702	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.5805582	0.4229857	0.8376199	0.8242373	0.7888482	2.428	131736	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.5805582	0.4229857	0.8376199	0.8242373	0.7888482	2.419	131771	35
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.5805582	0.4229857	0.8376199	0.8242373	0.7888482	2.423	131803	32
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.5805582	0.4229857	0.8376199	0.8242373	0.7888482	2.419	131837	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.5805582	0.4229857	0.8376199	0.8242373	0.7888482	2.423	131871	34
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	state	0.5291125	0.4277911	0.837499	0.8523871	0.7841867	2.419	131904	33
jordan	Apple Jacks-Closeup-AOI: 2	10000015-Closeup	Dwell End	0.5291125	0.4277911	0.837499	0.8523871	0.7841867	2.419	131906	2

After a participant views a package up close, a buy event looks like the following:

1	2	3	4	5	6	7	8	9	10	11	12
participant	itemviewed	stocknumber	action	excitement	meditation	frustration	boredom	long-term-excitement	EDA	msTimestamp	msDelta
jordan	Apple Jacks-Closeup	10000015-Closeup	Purchase							140717	0

This shows that whatever elements the participant focused on while reviewing the package, they moved him/her enough to buy the product. The levels of biometric response are recorded in columns 5-10.

Focus on EDA

For this document we're going to focus on the single skin-conductivity metric (Column 10) rather than the multiple (Columns 5-9). The manufacturer's literature indicates that the EDA readings, while clearly different from brain-state readings, are most similar to the "excitement" brain state in their overall patterns. What is meant is that momentary positive arousal is the brain state that is sought to be modeled from EEG input data (typically in µV from the various nodes in a brainwave headset) when the term "excitement" is used (typically using Fast Fourier Transforms tuned to a particular purpose), and momentary positive arousal is what is sought to be measured by the bracelet which sends an EDA signal. So they are equivalent in their goals of providing similar interpretive meaning to the pattern of signals.

Indexing required

People vary widely in their resting levels on all biometric measurements (reflecting differences between people in excitement, nervousness, etc.), thus requiring that we assess how they shift from

their own baseline. This indexing is common in market research, and is done by dividing measured levels by baselines, producing figures that show, say, "this participant is aroused 25% more than is usual for him or her."

The sales data was also transformed to indicate whether participants were moved to buy above base rates for the cereal products in question. An index was created that told us "Were you moved enough by what you saw to make your own personal Apple Jacks sales rate (say, 24%) higher than the normative Apple Jacks sales rate (say, 12)?"

Results

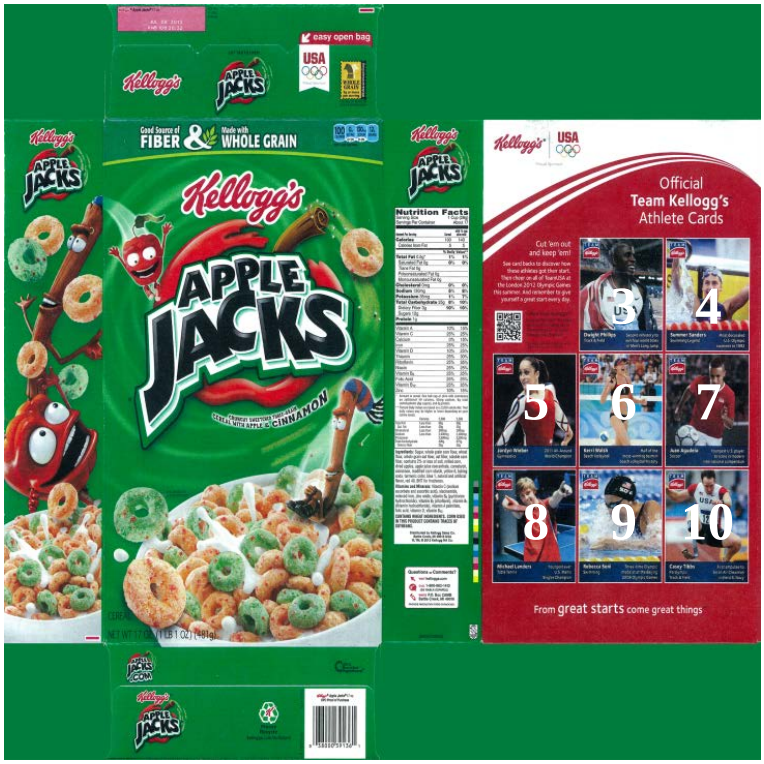
We were able to test the research question by running standard Pearson correlations on the transformed data. A sample dataset is shown in Figure 3.

Figure 3: Transformed Input Dataset

1	2	3	4	5	6
participant	itemviewed	EDA	EDA Index	Purchase	Purchase Index
curtis	Apple Jacks-Closeup-AOI: 19	0.073	107	0	0
curtis	Apple Jacks-Closeup-AOI: 19	0.073	107	0	0
curtis	Apple Jacks-Closeup-AOI: 19	0.073	107	0	0
curtis	Apple Jacks-Closeup-AOI: 19	0.073	107	0	0
curtis	Apple Jacks-Closeup-AOI: 19	0.073	107	0	0
curtis	Apple Jacks-Closeup-AOI: 19	0.073	107	0	0
curtis	Apple Jacks-Closeup-AOI: 19	0.073	107	0	0
jessica	Apple Jacks-Closeup-AOI: 19	1.688	62	1	134
jessica	Apple Jacks-Closeup-AOI: 19	1.678	62	1	134
jessica	Apple Jacks-Closeup-AOI: 19	2.23	82	1	134
jessica	Apple Jacks-Closeup-AOI: 19	2.337	86	1	134
jessica	Apple Jacks-Closeup-AOI: 19	2.333	86	1	134
jessica	Apple Jacks-Closeup-AOI: 19	2.073	76	1	134
jessica	Apple Jacks-Closeup-AOI: 19	2.073	76	1	134
jessica	Apple Jacks-Closeup-AOI: 19	2.06	76	1	134
jessica	Apple Jacks-Closeup-AOI: 19	2.069	76	1	134
kyle	Apple Jacks-Closeup-AOI: 19	8.977	108	1	96
kyle	Apple Jacks-Closeup-AOI: 19	8.818	106	1	96
kyle	Apple Jacks-Closeup-AOI: 19	8.977	108	1	96
kyle	Apple Jacks-Closeup-AOI: 19	8.806	106	1	96
kyle	Apple Jacks-Closeup-AOI: 19	8.965	108	1	96
kyle	Apple Jacks-Closeup-AOI: 19	8.818	106	1	96
kyle	Apple Jacks-Closeup-AOI: 19	8.977	108	1	96
kyle	Apple Jacks-Closeup-AOI: 19	9.081	110	1	96
leana	Apple Jacks-Closeup-AOI: 19	0.068	66	0	0
leana	Apple Jacks-Closeup-AOI: 19	0.068	66	0	0
leana	Apple Jacks-Closeup-AOI: 19	0.068	66	0	0
leana	Apple Jacks-Closeup-AOI: 19	0.07	68	0	0
leana	Apple Jacks-Closeup-AOI: 19	0.068	66	0	0
leana	Apple Jacks-Closeup-AOI: 19	0.07	68	0	0
leana	Apple Jacks-Closeup-AOI: 19	0.07	68	0	0

The resulting Pearson Correlations for the Apple Jacks AOI's are shown in Figure 4.

Figure 4: AOI Correlations on the Apple Jacks Box



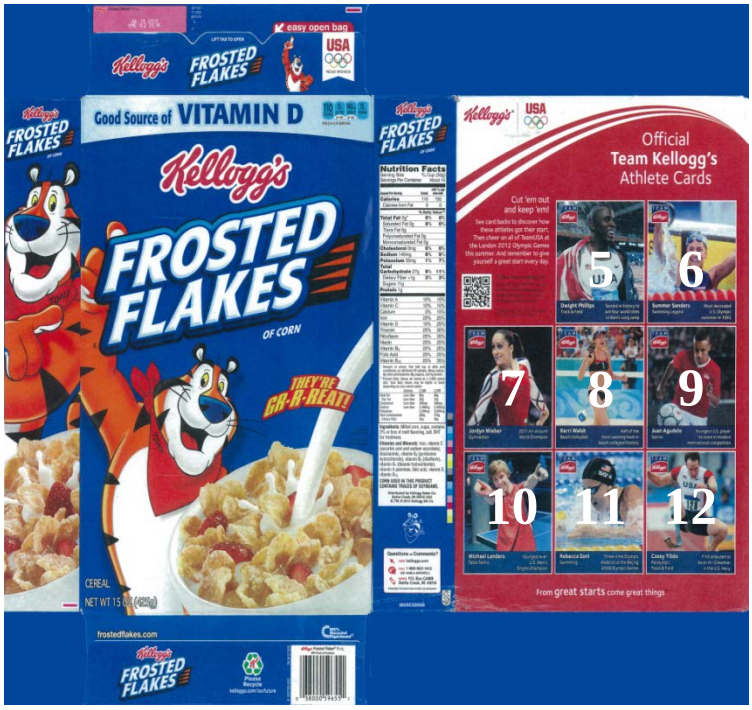
1	2	3
AOI	Description	r
1	Apple character on front	-0.28
2	Kellogg's logo on front	0.59
3	Athlete3	0.48
4	Athlete4	0.87
5	Athlete5	0.30
6	Athlete6	0.30
7	Athlete7	0.64
8	Athlete8	0.17
9	Athlete9	0.49
10	Athlete10	0.46
11	Cinnamon character on front	0.05
12	Apple Jacks logo on front	0.11
13	Kellogg's-Olympics text on back	-0.24
14	Official Team Kellogg's Athlete Cards	0.28
15	Cut' em out and keep 'em text on back	0.49
16	Kellogg's-Apple Jacks logo on right side	0.38
17	USA Olympics logo on top	0.16
18	Whole Grain seal on top	**
19	Fiber and Whole Grain text on front	0.31
20	Calorie info on front	**
21	Kellogg's logo on top	**
22	Apple Jacks logo on top	**
23	Kellogg's logo on left side	0.98
24	Apple Jacks logo on left side	0.99
25	Cinnamon character on left side	0.63
26	Apple character on left side	0.38
27	Kellogg's-Apple Jacks logo on bottom	0.49
28	Nutritional information on right side	-0.07
29	Questions or comments on right side	0.16
30	From great starts come great things on bottom	**
31	Easy Open bag text on top	**
32	Bowl of cereal on front	-0.20
33	Bowl of cereal on left side	0.76

**Base too small to calculate a correlation.

We see that attending to almost all of the Olympic athletes (r's from .17 to .87) correlated higher with sales indices than did attending to the cartoon characters on the front (r = .05), nutritional information on the right side (r = -0.07), or picture of the bowl of cereal on the front (r = -0.02). The Kellogg's and Apple Jacks brand logos also correlated highly with sales in their various positions on the package.

Although the images of all the athletes were not equal in correlating with sales, by and large the above pattern of findings was replicated on the Frosted Flakes package (Figure 5). At any rate, there is little evidence here to support the most critical stance that the Olympics promotion would have no appreciable ROI.

Figure 5: AOI Correlations on Frosted Flakes Box



1	2	3
AOI	Description	r
1	Kellogg's logo on front	0.09
2	Frosted Flakes logo on front	0.35
3	Tony the Tiger character on front	0.28
4	Bowl of cereal on front	0.09
5	Athlete5	0.70
6	Athlete6	0.16
7	Athlete7	0.54
8	Athlete8	0.54
9	Athlete9	-0.08
10	Athlete10	0.01
11	Athlete11	0.41
12	Athlete12	0.17
13	Kellogg's-Olympics text on back	**
14	Official Team Kellogg's Athlete Cards	0.43
15	Cut' em out and keep 'em text on back	0.88
16	From great starts come great things on bottom	**
17	Kellogg's logo on top	**
18	Frosted Flakes logo on top	0.11
19	Tony the Tiger character on top	**
20	USA Olympics logo on top	**
21	Easy Open bag text on top	**
22	Kellogg's-Frosted Flakes logo on bottom	0.33
23	Kellogg's-Frosted Flakes logo on right side	0.28
24	Nutritional information on right side	0.43
25	Questions or comments on right side	0.06
26	Good Source of Vitamin D text on front	0.21
27	Calorie info on front	0.84
28	Kellogg's-Frosted Flakes logo on left side	**
29	Tony the Tiger character on left side	0.51
30	Bowl of cereal on left side	0.54
31	They're G-r-r-reat text on front	0.26

**Base too small to calculate a correlation

Next steps for science and industry

We certainly believe that analyses such as these can inform business decision-makers about how to allocate marketing dollars, or resolve debates among designers over the effectiveness of very granular elements of packages. But by advancing the measurement rigor of research such as this, we believe that BioNimbus also opens the door to an broad and exciting range of applications.

Being able to correlate attentional focus, emotional reactions, and behavioral outcomes is of course attractive as a research technique. This type of protocol should be considered any time participants cannot validly report on their own internal states or external behaviors.

When is this likely? First, when the phenomena occur too quickly for people to semantically process them, like rapidly shifting attentional focus. Second, when the reactions and decisions are automatic and involuntary rather than effortful and controlled, like the memories and emotions primed by a logo that people may have seen since childhood. Third, when direct questions and self-reported answers are biased by social or emotional pressures, like whether we would honestly accept or reject a product for sale.

However, as we argued above, biometric research has to date been too slow, imprecise, and unverified to offer a valid research alternative. BioNimbus alleviates many of these constraints. It measures time intervals that are brief enough to match neurological realities. It verifies the attentional focus of participants rather than assumes it. And it synchronizes many forms of input and output to allow statistically rigorous correlations.

To that last point, this study looked at eye gaze (the input), skin-conductivity (the reaction), and sales proclivity (the behavior). But the ability to synchronize across different biometric devices

offered by BioNimbus allows us to swap out any of these measurements, allowing us to test research questions in very different contexts:

- How do airline passengers (the input) produce suspicion (the reaction) among security personnel resulting in hits and misses during screening (the behavior)?
- How does the layout of computing devices on a store shelf (the input) produce confidence and excitement (the reaction) and affect sales of tablets and laptops (the behavior)?
- How closely are a judge's instructions (the input) listened to and found to be credible (the reaction) resulting in jurors' adherence to applicable law in verdicts and sentencing (the behavior)?
- How are treatment recommendations (the input) felt to be inconvenient, painful, or frightening by patients (the reaction) resulting in non-compliance and adverse health outcomes (the behavior)?
- How do policy stances among politicians (the input) affect their perceived viability as a candidate (the reaction) resulting in votes and election outcomes (the behavior)?
- And of course, how does the sculpture in a fountain in a park (the input) give passersby a sense of peace (the reaction) and predict longer, more frequent walks through the lovely town of Edinburgh (the behavior)?

Questions such as these are simply too important to answer with conjecture or research methods that fall short of full validity. BioNimbus is an important step away from conjecture and toward precision.