What Can Neuroscience Tell Us About Why Print Advertising Works?

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A Paradox

Consumer demand for magazine media remains strong, despite a popular narrative that often portrays print magazines as going the way of the dinosaur. Consumers continue to read magazine media in their various forms and formats – in print and on the various digital platforms and devices on which they are available. In fact, when you tally up all of those platforms and points of contact, consumer demand for many magazine media brands appears to be more robust than ever (MPA, 2015). Consumers access their magazine media content via the web, different apps, video streaming services and even podcasts. As magazine media move into ever more diverse distribution channels, consumer demand grows apace.

Even when attention is focused solely on younger consumers and only on the traditional printed format, the audience trend statistics show greater aggregate consumer demand for many categories of print magazines now than in past decades (McDonald, 2011; McDonald, 2007). For such popular magazine media categories as fashion, celebrity, and men's interest, a greater percentage of Americans aged 18-24 read print magazines now than was the case 10 or 20 years ago. What's more, MRI data from 2014 show that 95% of Americans under the age of 25 read print magazines, the highest rate of all age groups (MPA 2015). Though critics sometimes point to declining newsstand sales as evidence of weak demand for print magazines. While it is true that newsstand sales continue a long decline, there are many factors other than demand that contribute to that trend: distributor consolidation, less frequent trips to supermarkets, rise of big-box stores, self-checkout, and ubiquitous smartphones have all reduced consumer exposure to newsstand facings and opportunities to impulse-buy print magazines. With the exception of newsstand sales, consumer demand for magazine media has been stable and, in some areas, growing. When considered along with the broader indicators of demand , there is something wrong with a media narrative that "print is dead" – at least from the perspective of consumer demand.

However the advertising side of the magazine media business has been much more problematic. The growth of digital ad spending has come at the expense of print, and even as magazine publishers have transformed their businesses to try to capture some of the growth in digital ad spending, they have struggled to make up the shortfall from declining print spending. As advertisers have become more interested in targeting technologies and applications of Big Data to create new occasions for ad messaging, their interest has waned in the older, more traditional, more expensive "quality" media. As Michael Wolff points out in his recent book "a large portion of the advertising business converted itself from its dual emphasis on print and television to a new emphasis on digital together with television (these became competing power centers within agencies)" (Wolff, 2015). Digital was cool, exciting and new. It attracted ever larger shares of marketer budgets, to the detriment of print magazines.

Yet there is a paradox here: though magazine publishers have to fight harder for advertiser dollars, magazine media, including the print format, consistently perform well in the quantitative market mix models that those same advertisers commission to evaluate the effectiveness of their media spending. These studies show that magazine media deliver strong advertiser ROI even when a lot of other media are in the mix (Briggs, 2013; Collins, Riggimenti and Vogel, 2007; Cardarelli et al 2007; Kilger and Romer, 2013; Kimelfeld and Phansalka, 2013; Bickel, Cleveland and Wood, 2013; Klein and Wood, 2013). These findings have been replicated in independent, media-neutral meta-analyses conducted by many of the leading firms in the field of market mix modeling, including Millward Brown, Marketing Evolution, Dynamic Logic, Market Share Partners, and others.

Studies based on market mix models tell us that magazine media perform well against such important advertiser KPIs as ad recall, persuasion, brand consideration, purchase intention and actual purchase – even when there is a lot of "noise" from other media present in the marketplace. But these studies don't give us a clue as to **why** magazine media continue to demonstrate such effectiveness.

It is the purpose of this paper to investigate this "why" question: Why do magazine media deliver the goods for advertisers – even when magazine audiences have been saturated with ad messages via other media? In particular, this white paper considers the possibility that the secret of magazine advertising performance may be the continuing importance of print-on-paper as a delivery mechanism for magazine media. After all, print-on-paper remains the unique province of magazines, newspapers, and direct mail. Among the media usually included in the market mix model studies (TV, web, magazine, radio), only magazine media offer a paper-based delivery vehicle. Perhaps there is something uniquely valuable about ad messages delivered through this venerable platform, and an impact on consumers that perseveres even in the digital age.

As it turns out there is a burgeoning academic literature on differences between reading on paper and reading on screen, much of it drawn from the new and exciting frontier of research in neuroscience. So the immediate purpose of this paper is to review that technical literature and translate it to a business-oriented non-technical audience. As input to this study, a scan was performed on the published research from the last 10 years in the leading peer-reviewed journals in the cognitive sciences – comprising neuroscience, cognitive psychology, learning & developmental psychology, linguistics and anthropology – to see what that research tells us about the difference between reading on paper and reading on screens in the context of modern digital environments.

Of course, there could be non-cognitive reasons for the persistent strong performance of magazine media in market mix models. Perhaps they extend the reach of an ad campaign to a degree not yet captured by our limited cross-platform media measurement. Perhaps because of their slower audience accumulation pattern, print magazines deliver their ad messages in a sequence and timing that amplifies the effects of the more immediate electronic media that consumers have already seen. Perhaps magazine media have more credibility, or they engage with consumers at a different and more receptive mood moment. Perhaps magazine media reach more influential consumers who then talk to their friends and activate network effects. Perhaps it is simply that ad messages received through different channels are more effective than ad messages repeated more frequently through the same channel. Over the years, various studies have explored these possibilities and none of them can really be ruled out.

But in this paper, we focus on the possibility that it might be our **cognitive processes** when we read print magazines that cause these impressive results in market mix models. There has been a lot of scientific research in the past decade on how our brains work. What light does this research shed on the differences between reading on paper and reading in a digital environment? It is the purpose of this review to bring this science to a broader business-oriented audience.

What Neuroscience Tells Us About How We Read

Before discussing the studies that compare reading on paper to reading on screen, it is worth spending a moment describing, in drastically simplified form, the work done by the hard-core cognitive neuroscientists to map the processes by which we read.

Seeing the Brain in Action

Brain imaging technology allows us to see what areas of the brain are activated when doing certain activities or encountering different stimuli. Cognitive neuroscience has shown that reading involves a suite of processes that sequentially activate different parts of the brain and involve not only visual, but also cognitive, affective and linguistic processes (and the brain regions associated with each). Accordingly, much of the literature under review here focuses on one or another sub-specialties related to reading:

- Visual processing and parsing of symbols
- Mapping symbol combinations (words) to a remembered lexicon
    - how words and contextual information are stored in memory
    - working memory, short-term memory and long-term memory
    - recall, comprehension and chronology reconstruction
- Attention, focus, and the brain "executive function" that directs our attention – together with those things thought to be the possible enemies of attention (distraction, multi-tasking, cognitive overload)
- Emotions generated by reading, especially as they affect memory & attention

- Multi-sensory dimensions of reading – including the study of "haptics", tactility, and the use of hands in the gathering and retention of information

Studies that compare human brain anatomy to that of other primates (or to our evolutionary ancestors) note that our species is distinguished by a much larger frontal lobe. This prefrontal cortex is linked to the rest of the brain by many more fiber bundles than are seen in other species. The higher cognitive activities of the human mind – including reading – involve significant levels of connection and communication between these different masses of neurons. While many parts of the brain are highly specialized, the prefrontal cortex does so much communicating with other parts of the brain that it is more multimodal – capable of processing diverse information inputs regardless of whether they come from touch, smell, vision or hearing senses. It is generally thought that the prefrontal cortex is the part of the human brain that most clearly differentiates us from other primates.

Visual Aspects of Reading

With reading, the process begins with visual activity. Because we use our eyes to read, the first part of the reading process involves activation of the visual processing areas in the back of the brain. This also requires brain processes that control the "executive attention" function by which we direct ourselves to engage our focus on something and then to move on to the next thing. These executive attention functions are at the front of the brain, so the initiation of the reading process involves a massive increase in connectivity between these disparate parts of the brain. When we learn to read, we learn to direct our focus along lines of text via small movements (saccades) followed by very brief pauses (fixations). The eyes of the average adult take in about 8 characters in each saccade and, of course, we also backtrack sometimes and re-read, usually about 10% of the time. However through this process, as we learn to read, we come to recognize whole words. In brain mapping terms, these symbol recognition functions activate specific occipital temporal areas in the back of the brain.

Interpretation, Understanding, Remembering

The second step in the reading process involves memory. Scientists generally differentiate between short-term memory (what we hold in our minds for a few seconds, usually limited to just a few words, numbers or images), long-term memory (what we retain for future reference), and working memory (what we put together from our short- and long-term memory as part of our active process of comprehension and interpretation). Much of this sorting out of stimuli in our working memory process – what we might otherwise call "thinking" – takes place in the prefrontal cortex as it communicates with the other more specialized parts of the brain. The neurons in our prefrontal cortex demonstrate a remarkable ability to process thoughts well after the stimulus (perceived object, word, or sound) has disappeared. However many things that occupy our working memory do not get retained. Those that we remember briefly are said to be lodged in our short-term memory, but the duration of retention is measured in seconds. Short-term memory is very finite: experiments suggest that we usually can only hold 7 items in short-term memory (give or take 2). And many things that pass through short-term memory do not "stick" with us – which is to say that they are not encoded into long-term memory. Long-term memory may not have infinite capacity, but it is so large as to defy experimental measurement. Research has shown that the hippocampus, a small area deep in the center of the rear (posterior) of the brain, is critically involved in the process of encoding from short-term to long-term memory and that is also involved in regulating our emotions.

So the second step in reading involves shifting from our visual system to our interpretive and memory functions. Once we perceive words, we engage the parts of the brain associated with semantic memory – our internal dictionary of remembered word meanings and associations. This often involves phonological processes too where we actually "hear" the words in our minds. These semantic and phonological processes are key to our comprehension and they involve other brain areas in the posterior lobes – most especially the angular gyrus, the area where we make meaning associations. As we become more fluent in reading, we increasingly activate the hippocampus with its ability to encode information into long-term memory. But since the hippocampus is part of the limbic system, our reading is also activating the part of the brain that connects emotions (love, sadness, disgust, anger) to cognition. Our emotional responses to what we read may indeed help to determine what we transfer into long-term memory. This may be an important neural mechanism by which we have such emotional responses to some of the things we read, why avid readers can get enjoyably "lost in a book". And perhaps it is one neuroscientific key to the persuasive power of reading.

The Principle of Brain Plasticity and Worries about Digital Reading

Cognitive neuroscience has also discovered that the brain is extraordinarily "plastic" – meaning that it adapts quickly to changes in conditions. Indeed, the brain is not really pre-programmed to read; rather it must be learned. We are genetically pre-programmed to feel, see, smell, think, move and hear. But there is no "reading gene" and indeed we only became a reading species in the relatively recent past – about 5500 years ago – too recently for our genes to encode the behavior directly. While we don't have to be taught to feel, see, smell, or hear, we need to learn to read – each individual and each generation anew. It is the plasticity of our brains that allowed us to develop the cognitive processes to support reading (Wolf & Barzillai 2009; Dehaene 2009). The eminent French neuropsychologist Stanislaus Dehaene, probably the foremost expert on the neuroscience of reading, explains that we taught ourselves to read by "recycling" some neural circuits that had evolved for other purposes and were previously used to identify and respond to objects, like dangerous snakes, that we already remembered from prior exposure (Dehaene 2009).

Brain plasticity is demonstrated in a lot of the research on cognition. If a brain is damaged by an injury or by a condition like dyslexia, it might try to recover and compensate by shifting the burdens of mental processing to a different part of the brain. Plasticity also figures prominently in discussion of the role that reading plays in perpetuating inequality between more affluent children raised in environments that have rich language opportunities and those that come from linguistically impoverished environments (Griswold, McDonnell and Wright, 2005). Indeed one major study found a 32 million word gap between impoverished kindergarteners and more advantaged, stimulated kindergarteners from more middle-class families (Wolf 2007). The middle class children enter kindergarten not only with better vocabularies and richer contextual information to allow easier reading comprehension, but the brain imaging studies show more neural activation and connections between brain areas that are engaged when reading. Research in this tradition provides a strong argument for the benefits of early childhood education, free pre-school, and the like.

Plasticity is also evident in the cross-cultural studies of reading. Researchers have developed the notion of the "universal reading brain" – referring to the key areas of the brain that work the same in all languages. However they also have found from brain imaging research that our reading processes are not entirely universal. Indeed, reading ideographic languages like Chinese (with more than 900 characters) involves different brain activations than reading alphabetic languages. And even among alphabetic languages, there are differences between the more orderly and structured languages (like German or Italian) and the more erratic and exception-prone languages (like English). However there are some limits to brain plasticity that constrain the development of reading and writing. For example Dehaene notes that reviews of 115 different languages and their associated writing systems still only show symbols of no more than three strokes – and usually only of one or two. This seems to be a natural limitation of our ability to recognize easily the geometric shapes that make up letters, words and languages.

This principle of brain plasticity is important to this literature review because a lot of the research on reading from screens poses questions about how our digital technologies are changing the very structure and functions of our brains (Doidge 2007; Poldrack and Sendak 2004; Yarkoni et al 2008; Small and Vorgan 2008; Baron 2015). Many scholars who study reading have worried that our brains are being rewired in negative ways. These concerns reached popular audiences with the Atlantic's publication in 2008 of David Carr's "Is Google Making Us Stupid?" That provocative article – later expanded into an even more provocative book (Carr 2010) – continues to inform much public discussion of the implications of our obsessive use of internet-connected devices.

Another theme explored in the cognitive neuroscience literature concerns the possible negative impact of "cognitive load" imposed by both the volume and hyperlinked nature of digital information. Research in this vein explores the possibility that hyperlinks distract us from taking in the logical flow of linear information and thus undermine our ability to comprehend and remember. Some researchers focus on the emotional stress said to ensue from constantly having to decide whether to veer off on a hyperlink or to stay with the flow of material with which you started your reading session. Some of this literature combines a critique of the distraction of hyperlinks with a worry about the sheer volume of information unleased by the digital era. Indeed, even Google's CEO, Eric Schmidt, was quoted in 2009 as sharing a concern that the "level of interrupt, the overwhelming rapidity of information…is affecting cognition. It is in fact affecting deeper thinking. I still believe that sitting down and reading a book is the best way to really learn something." (quoted in Carr 2009).

Even though there is general agreement that the internet has opened up access to vastly more information than ever before, psychology research raises concerns that it is changing us in unpredictable ways. Tufts developmental psychologist Maryanne Wolf, a leader in reading research, worries that we may be drifting from the "reading brain" that supported us for

millennia to a "digital brain" with unknown implications. Harvard historian Robert Darnton (2009) writes that we can "feel the ground shifting" below our feet. Clearly many of the scholars thinking about reading are feeling unsettled.

So what do we really know about the difference between reading on paper and reading on screens? As is usually the case in scholarship, there is not perfect consensus. However there are some points of convergence.

What Do We Know About Paper vs. Screen Reading?

Scanning Versus Deep Reading

The preponderance of research suggests that reading online tends to be faster and more superficial than reading on paper. Even studies of the reading habits of academics show a tendency toward "horizontal" reading – skimming and scanning and bouncing – when reading online (Rowlands et al 2008; Nicholas et al 2008). Some of this behavior was highly purposeful rather than distracted, a process described as "squirreling" – a hunt for nuggets to download now and read later. But it still represented a fast and horizontal mode of reading that, as Maryanne Wolf points out, would not lead to a very satisfying immersion in something like Joyce's Ulysses.

An influential study by Zeming Liu (2005) described screen-based reading behavior as "characterized by more time spent on browsing and scanning, keyword spotting, one-time reading, non-linear reading, and reading more selectively" while correspondingly less time was spent on in-depth reading and concentrated reading, on annotation and highlighting. Overall, Liu found lower levels of sustained attention when reading was done on screens. This echoed earlier work done by Mayes et al (2001), and Wastlund et al (2004). Some recent studies have found negligible or ambiguous differences in reading speed or eye movement (Noyes and Garland 2008; Ackerman and Goldsmith 2011; Zambarbieri and Carniglia 2012), raising the possibility that as the population becomes more digital the speed differences found in earlier studies will diminish. However others have argued that the matter is far from settled since the studies have not controlled for all of the variations in types of reading (pleasure, study, information) and for types of readers (Cull 2015, Baron 2015).

In general, the preponderance of research on reading speed indicates that paper-based reading is slower and more deliberate while screen-based reading is faster and more superficial. While the implications of these differences for advertising effectiveness have not been studied systematically, the examples from the cognitive sciences suggest that effective digital ads need to be highly telegraphic while print ads have the opportunity to seduce the reader into a longer engagement – to put themselves into the picture or to fantasize taking the trip, wearing the clothes, driving the car, or being the subject of the ad.

Comprehension and Recall

More important than speed is the question of reading comprehension. Here there is a bit more consistency among the studies identified thus far in this meta-analysis. Of the 31 studies found in our literature scan, 26 of them reported finding higher comprehension when the reading was done from paper rather than from a screen. Four studies found the opposite, and one study found that comprehension results depended on the specific conditions of the experiment. Many of these studies took place in educational settings spanning grade levels from elementary school to college. As such, the studies differed considerably in what criteria they used to measure comprehension (multiple choice questions, plot order reconstruction, memory of facts, understanding of concepts). They also varied in the length and complexity of text to read and comprehend, and in the time between reading and testing.

One of the more interesting of the recent experiments that measured reading comprehension came from renowned Israeli psychologist Rakefet Ackerman and his associate Morris Goldsmith (2011). They tested college students' ability to learn from five different difficult texts delivered either on paper or digital platforms. Regardless of the platform they were using, the students were told to annotate, highlight, comment and engage with the materials in the same way that they normally would when studying. In one form of the experiment, the time allotted to the texts was strictly limited; in the second form, students could spend as much time as they liked with the texts. The study found that when timing was limited, the paper vs. digital difference in comprehension was negligible. However when timing was unrestricted, the students reading on paper scored about 10 points higher than the students reading on screens. The researchers also asked the students to rate how well they had learned the materials and found that the paper-based readers could predict their performance nearly perfectly, while the on-screen readers considerably over-estimated their scores. The researchers concluded that the more natural conditions of the second, untimed experiment allowed the paper-based readers to apply better "metacognitive" strategies to regulate

their comprehension of the material, and they had a surer sense of the degree to which they had understood what they were reading. In effect, they did a better job of monitoring their own learning.

A separate study by Sara Margolin (2013) found similar advantages in comprehension for paper-based learners, but her study shed further light on the metacognitive strategies of her subjects. She found that the students reading text on e-readers were more reluctant than paper-based students to turn back pages to re-read material already consumed. In effect, they felt compelled to swipe forward rather than review to make sure they understood. The result was poorer overall comprehension.

Some have suggested that reading on paper makes it easier for students to make a mental map of the material they are trying to learn – thereby comprehending a temporal or spatial sequence (e.g. Baron, 2015).

The studies under review provide fairly strong and consistent evidence that paper-based reading is associated with stronger transfer to long-term memory, recall and overall comprehension. However they also suggest that environmental factors – like time constraints and expectations of available time - can affect recall and comprehension. As we are about to see, the "noisier" environments of digital media consumption come in for particular scrutiny in the cognitive science literature.

Hyperlinks, Multi-Tasking and Cognitive Load

A lot of the newer research on reading on screens vs. print focuses particularly on the problem of distraction arising from the noisier digital environment. While research in the early 1990s often concentrated on screen contrast and optical strain as factors in comprehension of on-screen material, the growth of the World Wide Web and HTML led to greater research attention to the benefits and liabilities of hyperlinks, for example. For example DeStefano and LeFevre (2005) found that reading hypertext imposed increased demands of decision-making and visual processing, to the detriment of reading performance. This was especially pernicious for readers with low working memory and low prior knowledge of the subject material; they found that such readers benefited particularly from conventional linear format, the format associated with the paper platform. In this view, it is not the delivery device per se that affects reading comprehension, but rather the additional cognitive load imposed by hypertext. A similar result was recently reported by German researchers using advanced electroencephalographic (EEG) and eye tracking measurements to measure cognitive load when reading hypertext (Scharinger, Kammerer and Gerjets, 2015).

The literature is divided on the question of whether "digital natives" ultimately develop a style of hypertext reading that is optimally adapted to the digital environment. While some studies have found slight differences among age groups or between sub-groups with varying levels of digital experience, the findings are not terribly consistent on this point. Some have found that those more habituated to hyperlinked digital environments (e.g. heavy gamers) are better at switching behavior (successfully pivoting their attention from one thing to another, and then back again) than are those more steeped in the linear reading tradition. However a recent carefully controlled experiment surprised the researchers by finding just the opposite: heavy multi-taskers trying to learn complex material about the theory of probability were more susceptible to interference from irrelevant environmental stimuli and were more likely to make irrelevant representations in their memory. As a result they performed worse on task-switching activities than did those who typically shun multi-tasking (Ophir, Nass and Wagner, 2009).

Of course distracted reading and multi-tasking while reading is not a new phenomenon (reading while watching TV or listening to the radio, for example). However the growth of hypertext concurrent with the other appurtenances of the online environment (multiple windows open, email alerts, RSS feeds, fantasy football scores, stock quotes, social media updates, cell phone text messages, digital display ads, etc.) leads to a condition quite at odds with "deep reading" and understanding. This has led to considerable consternation about the ability of the younger generation of digital natives to sustain their focus and think deeply (Thirunarayanan, 2003; Carr, 2010; Cull, 2011). However as Maryanne Wolf notes, we have no longitudinal data to monitor the long-term impact of reading in the complex digital environment, so it is difficult to make empirical assessments. As she puts it, "we are in a place of apprehension rather than comprehension" (Konnikova, 2014).

In total, this review identified 20 studies reaching similar conclusions: hyperlinks are associated with lower comprehension and recall. Some studies indicate that the hyperlinks require that people make micro-decisions about whether to continue or whether to follow the hyperlinks. These decisions sometimes produce negative emotions (anxiety or stress) that add to the mental "noise" in the reading environment. Thus even though on-screen reading can be very fast and purposeful, it is also prone to be distracted and unfocused.

Haptics, Tactility and Multi-Sensory Reading

Not all scholars studying reading agree that hypertext is the only culprit in the lower comprehension scores of on-screen readers. For example, Mangen et al (2013) randomly assigned 72 Norwegian 10th graders to two groups reading identical linear texts on paper vs. computer screens and found that those who read on paper scored significantly better on reading comprehension than those who read on screen. This echoed results from other experimenters who controlled the stimuli to focus more precisely on the effect of the presentation medium on comprehension (Wastlund et al, 2005; Noyes and Garland, 2003).

Anne Mangen and her Norwegian associates have produced a considerable body of work calling attention to the **haptics** of reading – the way in which we use our sense of touch and motor skills to supplement the more purely cognitive components of reading. In her view, digital text is volatile and intangible, detached from the physical medium that delivers it. This differs in critical ways from the materiality of printed text; in other words, clicking and scrolling affect our relationship to what we read in ways quite different from the relationship engendered by holding paper and turning pages. By focusing on the motor-sensory aspects of reading, she hopes to challenge the purely cognitive focus of much of the research on reading. Her work, drawing on the theories of phenomenologists like Merleau-Ponty, questions the traditional Western separation of mind and body. She draws on the work of evolutionary biologists to remind us that our brains evolved in reciprocal relation to other anatomical changes – particularly the development of bipedal walking, the freeing of hands to make gestural communications, and the subsequent co-evolution of gesture and language. Researchers in this tradition (Arbib, 2005; Corballis, 2002) hold that the neural structures supporting hand gestures were critical to the development of language and, through that, to reading. This school of thought highlights the role of hand gesture, facial expression, finger movement, and body motions in the way that people communicate in everyday speech and argues that we don't just read with our eyes and brains, but also with our hands. When translated to the digital world, they study the effect of weight, format, form factor, and other ergonomic elements on reading and consider how to optimize the reading experience for digital environments (Hillesund, 2010).

Some work in this vein concludes that print-on-paper remains superior for learning and digesting complicated texts while text-on-screen is better for quick information gathering and browsing (Stoop et al, 2013; Liu, 2012). Others (Mangen 2008; Baron, 2012) are less certain of the efficacy of digital text, arguing that its very immateriality (aggravated by the distraction of hypertext) prevents us from immersing ourselves in online reading. More recent studies that compare reading on tablets and e-readers continue to show less narrative engagement and more distraction when reading is done on the screen, compared to paper (Mangen and Kuiken, 2014).

One important school of thought in cognitive psychology argues that how we learn things is critically important to memory and recall. Researchers in this tradition of multi-sensory learning theory have shown that material that we both read and hear aloud is remembered better than material only read or only heard. Other researchers have found that students reading digital texts remember what they have read far better when they make handwritten notes of their reading, compared to those who annotate those texts on screen using software (Coiro, Knoebel and Lankshear, 2015; Eden and Eshet-Alkalai, 2012). Most recently, researchers studying foreign language acquisition among adults divided their subjects into three groups: one group only heard words and translations; the second heard the word and then had to make a gesture related to the word; a third group heard the word and drew a picture related to the word. The researchers used fMRI measurements to map the neural activity associated with these three different learning tasks. They concluded that the multi-sensory groups had greater and more diverse neural activity and that their comprehension and recall were significantly higher than the mono-sensory group (Mayer, Yildiz, Macedonia & von Kreiegstein, 2015).

The neuroscience explanation for this phenomenon is that we recruit different parts of our brains to encode information that we see, hear or feel to the touch. Thus, according to this view information gathered through multiple platforms and multiple senses – including advertising stimuli – is more likely to be grasped and remembered. Multisensory coding also gives you more recall triggers.

Emotion and Memory Retrieval

Researchers who focus on the haptics of reading argue that the tactility of paper and the materiality of ink on paper tap the very deep neural structures that we developed along with language itself, and that this in turn leads to higher emotional engagement with what we are reading (Mangen and Kuiken, 2014). This aligns with neuroscience studies of direct mail finding that ads on physical materials like paper generate more emotional processing – partly because of the motor processing associated with their consumption – than do digital ads (Millward Brown, 2009, 2015).

Indeed a recent study of direct mail by neuroscientists at Temple University (Dimoka et al, 2015) compared responses to on-paper to on-screen advertisements among 56 adults using measures of attention (eye tracking), arousal (skin conductance and heart rate), and neural activity (fMRI). They found that respondents were more likely to remember an ad and its context one week after exposure if that exposure had been to the physical/paper version of the ad as compared with the immaterial/screen version of the ad. This better ad recall was mirrored in the fMRI's brain mapping by increased activation of the hippocampus and the parahippocampal place area (PPA) during memory retrieval. Print-exposed respondents also showed more certainty about their recollection, as measured by time to respond to the investigators' questions. Though there was no expressed difference between the print and digital groups in stated willingness to pay for the advertised product, the print-exposed group showed significantly higher activity in the ventral striatum, an area associated in previous research with reward processing and desirability (Gregorios-Pippas et. al., 2009; Berns & Moore, 2012; Ventrakaman et.al., 2015; Linder et.al., 2010; Knutson et. al., 2007). Though the Temple neuroscientists shy away from characterizing the ventral striatum as the brain's "buy button", their description of its function sounds very close to a marketer's dream.

Intriguingly, haptic research unrelated to reading makes a similar association between tactility and perceptions of desirability (Ackerman et al, 2010). In this instance, researchers experimented with the heaviness of materials as a predictor of non-conscious impressions and decisions. Among other findings, they reported that resumés on heavier clipboards made job candidates appear more important. They concluded that tactile sensations affect our judgments in ways that are not accessible to our conscious minds – a conclusion that is congruent with the Temple finding of no difference in consciously stated willingness to pay, but higher activity in the ventral striatum.

Relatively little neuroscience research has been done comparing memory encoding in response to paper vs. screen reading. A UK study sponsored by News UK found no difference between paper and tablet recall of newspaper content presented in the same linear, non-hyperlinked format. However it found that tablet presentations were associated with higher levels of visual stimulation and faster reading, while paper-based reading stimulated slower reading and higher levels of emotional response (Adams, 2015; Kaul et al, 2015). A German study (Kretzschmar, 2013) examined book reading on tablet, e-reader and paper among younger adults (18-34) and older adults (60-70) using eye movement and EEG measures of theta band voltage density (thought to covary with memory encoding). The young adults showed no differences across platforms, but the older adults scored lower on the EEG measures. In the United States, the Millward Brown study already mentioned (2009) found evidence of stronger memory encoding among those who encountered the physical format direct mail pieces, compared to the digital format subjects. Their data suggest that the paper format stimulates a stronger emotional response that, in turn, makes the materials more memorable.

In sum, research in this area does not enjoy quite as much consensus as in other areas, partly because many studies have not rigorously controlled for the difference between linear and hyperlinked presentation formats. Nevertheless the available research does provide strong indications that paper-based reading leads to better memory encoding and to activation of parts of the brain associated with reward processing and desirability. If further replicated by future and better-controlled research, these findings could provide a powerful explanation for the positive performance of print magazines in market mix model studies.

Format Preference

This tendency, reported in several of the studies, to find a stronger emotional response to content delivered on paper may account for the surprisingly robust finding that people still express strong preference for print-on-paper for reading. Indeed, in nearly every study found in this scan that asked respondents direct questions about their preferred format for reading, paper came out on top – even among younger consumers and "digital natives". Of course, most of these studies were focusing on educational materials, literature and long-form texts – so the preference results might have been different had the context or type of content been different. But given this review's findings related to tactility, hypertext distraction, and emotional response to paper-based media, the preference for paper might well extend to other media.

Indeed, longitudinal studies and cohort analyses of long-term magazine reading patterns show persistent – and even growing – consumer demand for print magazines in several important genres and across all age groups. In fact, the increased aggregate demand for print magazines in the fashion, celebrity and men's categories is MOST pronounced among members of the Millennial generation, compared to adults in the same age group 10 and 20 years ago (McDonald, 2011; McDonald 2007). And despite the widespread availability of digital editions of magazines on tablet devices as free add-ons to print subscriptions, the evidence thus far suggests that the vast majority of magazine readers continue to read their printed versions.

Thus, even though measures of preference do not require any advanced neuroscience insights or passive behavioral metrics, they could provide another clue to the robust performance of magazine media in market mix models: print-based media gratify basic consumer preferences and thus provide a congenial and relaxed framework for ad messaging.

Conclusion and Executive Summary

Print magazines have consistently been strong ROI performers in advertiser-sponsored market mix models, even when used in conjunction with other media. This meta-analysis looks to the field of cognitive neuroscience to search for possible explanations for this advertising impact.

Neuroscience has made enormous strides in the past decade and is now one of the most exciting fields in the natural sciences. Though the field is still young and there is an emerging body of work emanating from it that is helping to highlight differences in the ways that our brains respond to information presented on paper compared to information presented screens. In conjunction, with studies using more traditional behavioral tools, including surveys, eye-tracking, question and answer testing, this literature suggests that:

- Reading on paper is slower and deeper, while reading on screen is faster and more in "scan" mode
- Paper-based reading benefits from more focused attention, less distraction, less anxiety related to interruption, multi-tasking and cognitive load
- Paper-based reading is widely associated with better transfer to long-term memory and clearer comprehension
- Memory and comprehension from paper-based reading is likely enriched by the multi-sensory experience of holding and manipulating paper
- In the case of advertising, print advertising activates neural activity associated with desirability and reward

While the evidence is still accumulating and we do not yet have enough to **prove** that the consumer response to the venerable paper platform is the "secret sauce" that causes the consistent high performance of print magazines in advertiser-sponsored market mix models, we can't rule that possibility out given the findings in the burgeoning field of cognitive neuroscience. In the quaint language of an older form of scientific inquiry, we can at least reject the null hypothesis that there is no relationship between reading platform and reading comprehension.

If the evidence adduced in this review is supported by future research, it raises questions about those advertisers who are replacing print exposures with digital. Not only are they disregarding consumer demand for print, they are also ignoring what may be print's superior ability to deliver a reading experience which supports comprehension and retention of -- and connection with -- their message.

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