The 2nd International Conference on Design Creativity (ICDC2012)
Glasgow, UK, 18th-20th September 2012

BIOLOGY AND THE WRITTEN WORD

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Abstract: In a contemporary society of vast computing tools and cutting-edge design software, the possibilities of image making and typesetting are boundless; there is virtually no limit to the potential for creativity. The brain itself, the source of this creativity, is similarly capable of remarkable feats—advanced logic, an immeasurable memory capacity—yet we experience our world solely through our senses, knowing only what the brain interprets of the body's incoming electrical signals. In the context of graphic design, written language, developed using such fundamental sensory input, makes full use of this processing power. It raises questions regarding the nature of sensation, perception, and its own representation in the hands of a designer. With the awareness of these biological processes comes an understanding behind the artistic judgments we make as designers; we can take advantage of this knowledge to make better, more effective creative decisions.

Keywords: *Typography, Perception, Synesthesia*

Written language surrounds us— it instructs, entices, warns; it scolds, informs, and tells stories. A contemporary designer strives to find order amidst the chaos and communicate ideas with a deliberate manipulation of images and accompanying text. With vast computing tools and cutting-edge design software, the possibilities of image making and typesetting are instantaneous and limitless, allotting boundless creativity. The brain itself, the source of this creativity, is similarly capable of amazing feats—advanced logic and reasoning, lightning-fast associations and interpretations, and immeasurable memory capacity—yet we are tied to our world solely through our senses, knowing only what our brain interprets of the body's incoming electrical signals. In the context of graphic design, written language, a sign system of communication unique to humankind, takes advantage of our senses and mental processing power alike; it becomes a remarkable entity in and of itself, raising questions about the nature of sensation, perception, and even its own representation. With the awareness of these biological processes comes an understanding behind the compositional judgments we make as designers; we can take advantage of this knowledge to make better, more effective creative decisions.

One exceptional example of human sensory capability is the rare condition known as synesthesia. From the Greek *syn* (union) and *aiesthesis* (sensation), the term *synesthesia* literally refers to a coupling of the senses. It is largely a sensation of parallels; the true neurological input from one sense induces a concurrent perception in another. This additional awareness is often just as real to the synesthete as his initial perception of reality, occurring not necessarily within the mind's eye but rather outside the body and in the environment (Cytowic, 1989).

This effect, however, is completely involuntary; a synesthete has no control over the supplementary sensations of his condition, nor can he control the sensory modalities it affects. Synesthesia, therefore, is not a product of the mind but rather the brain. A departure from human evolution's general tendency toward sensory separation, this multi-level marriage of perception has nothing to do with the imagination and everything to do with the neuron (Cytowic, 1989). Though the direct cause of synesthesia is still largely a psychological and neurological mystery, renewed interest in recent years has brought about fresh studies and interviews that demonstrate a remarkable consistency amongst participating synesthetes. Highly advanced scanning technology known as DTI (Diffusion Tensor Imaging), for instance, has allowed researchers to study the connections between regions of the brain in detail. In subjects with synesthesia, the results of these scans have shown an increased connection between those areas responsible for processing the associated modalities (Than, 2011). For example, grapheme/color synesthesia is a particular breed of the condition in which letters or numbers (graphemes) elicit specific colors. When shown simple, colorless graphemes in one study, participants' scans indicated that two areas of the brain were activated simultaneously—the grapheme region, and region V4, part of the visual cortex that typically responds more strongly to colored stimuli than grayscale stimuli (Brang & Ramachandran, 2011). This provides further evidence that synesthesia is indeed intrinsically sensory. It also demonstrates that bottom-up processing is at work to produce synesthetic effects rather than strong psychological or cognitive affiliations (Brang & Ramachandran, 2011).

This discovery may also explain why the majority of sensory crossovers operate only in one direction—for example, numbers may trigger a color response, but colors will not conjure numbers in return. Were synesthesia a psychological function, it would be more likely to produce a reciprocal association (Brang & Ramachandran, 2011).

As science continues its investigation of the phenomenon, similarities and parallels in firsthand accounts have also contributed to a general acceptance of the condition being neurological. Like Wittgenstein's discussion of color adjective inadequacy, synesthetes encounter similar "language game" limitations when attempting to describe their experiences. Early misunderstandings of the condition in the nineteenth century occurred as a result of detailed patient accounts. Because of the vivid nature of their experiences, synesthetic characteristics were often misattributed to symptoms of schizophrenia and other serious psychological disorders. They were also commonly classified as hallucinations (Than, 2011). Another, later problem to arise from patient description was the psychological assumption that language itself was the link in synesthetic perception. This was likely due to the fact that the synesthetic experience cannot accurately be recreated; verbal communication is the only way to share and label what a synesthete sees, hears, smells, tastes, or feels in response to specific stimuli (Cytowic, 1989).

These verbal interpretations of the sensory experience are not simply a relay of the imagination; rather, they are descriptions of actual autonomic responses, and their language games are a code in which something is always lost in translation. Multilingual Russian novelist Vladimir Nabokov, a grapheme/color synesthete, attempted to describe his condition in his fictional characters and later, on a more personal level, in his autobiography *Speak, Memory*:

"The long *a* of the English alphabet […] has for me the tint of weathered wood, but a French *a* evokes polished ebony. This black group also includes hard *g* (vulcanized rubber) and *r* (a sooty rag bag being ripped). Oatmeal *n*, noodle-limp *l*, and the ivory-backed hand mirror of *o* take care of the whites. […] Passing on to the blue group, there is a steely *x*, thundercloud *z*, and huckleberry *k*." [emphasis added] (Nabokov, 1970)

Nabokov built his identity as a man and a writer on the foundation of his synesthesia. Much of his self-analysis (as evident in his autobiographies) is direct response to his synesthetic experience, which he in turn applies to his written work (Foster, 1993). His last Russian novel *The Gift* can be read as a self-reflexive parallel to his own life, with the protagonist Fyodor caught between past and future and consequently struggling to define himself as an author. Fyodor experiences "colored hearing" in the story and uses it to assert his originality as an artist, allowing his synesthesia to function as a launching point for creativity. He also uses it as a tool of remembrance to revisit his past; his feelings

and memories come to life in vivid color when, for example, he recalls his mother's jewels (Foster, 1993). This references Nabokov himself, whose mother was also a synesthete and encouraged him as a child to embrace this unique quality. As it turns out, his wife and son experienced similar letter and color associations, suggesting a familial link (Foster, 1993).

Indeed, synesthesia is largely a heritable condition; it can be passed genetically from parents to offspring across multiple generations. However, it can also occur in non-synesthetes as a response to drug use, brain damage, or sensory deprivation. Because the major difference in the brains of synesthetes is increased connection strength between separate processing areas, some researchers have made the case that all humans have the potential for synesthesia and consequently the potential for an expansion of creative thinking (Brang & Ramachandran, 2011). Repeating an action can increase the strength of neurons, demonstrating the remarkable plasticity of the human brain. *Practice makes perfect,* as the familiar phrase goes; the more frequently one performs a task, the more skilled one becomes at that task. And with enough exposure, it becomes like "second nature," requiring less direct concentration. The mind, then, is free to focus elsewhere—more effort can be dedicated to finding original solutions to problems at hand.

A wonderful example of this is reading comprehension and the written word. We learn to read and write at a very young age, an ability that exposes us to an endless feed of information and knowledge in our contemporary environment. Basic semiotics are at work here: our ability to glance at a set of shapes (letters, the signifiers) and recognize them as possessing a meaning in a certain arrangement (the signified) is essential to our understanding of signs (words) and the world around us. (Bouissac, 2010). Another way to look at language is that letters become signifiers for sounds; written words become signifiers for their spoken equivalent.

We deal with all three automatically. While reading, we instantaneously recognize arrangements of letters as specific words with specific meanings. Were someone to ask us to read aloud, we would know exactly how to translate what we see to something we hear. These concepts become tightly entangled as we progress through life, expanding our vocabularies and cementing our existing comprehension of word signs and their meanings. Because we are no longer forced to devote our attention to the *process* of reading (which has now become an automatic operation), we are able to focus on the *content* and the broader picture, piecing together these meanings into sentences, paragraphs, and narratives.

Adjectives in particular hold a certain contextual power; they have the ability to evoke multiple senses in the imagination. Descriptors have the ability to modify, to manipulate; they can change our experience or understanding of a text. A voice may be mellifluous or grating, a surface polished or gritty, a breeze perfumed or pungent, a drink sweet or bitter. They transform our understanding of the given content in a way that we cannot alter.

So engrained are the meanings of these multi-sensory adjectives that we cannot help but experience them, in one way or another, as we read. Color words are perhaps the best example of this. When we read the word "yellow," we know immediately what it describes; a memory of the hue appears before our mind's eye regardless of the literal word's appearance. Displayed on this page, for example, the word "green" is not actually green, but without conscious thought or decision, we imagine and experience the true shade it represents. The same reaction occurs with "red," "orange," "blue," and "purple"—a veritable rainbow of color recorded in black, vibrant and flowing within our minds.

It is this involuntary reaction that makes written language a synesthetic catalyst for its own comprehension. Of course, it differs from natural synesthesia in that non- synesthetes do not perceive the second sense *outside* the body; their associations originate and remain in the mind, a sort of top-down processing. But like true synesthesia, expo- sure and repetition strengthen neurological connections in the literate brain, rendering these word/sense associations instantaneous and involuntary.

Also like true synesthesia, the sensory responses from written language can bring about physiological or emotional reactions. For example, the word "sour" may cause salivation or a tingling jaw; the written phrase "nails on a chalkboard" may inspire a cringe and cause discomfort. Not all synesthetes'

experiences are pleasant either; a first-hand account of one woman chronicled how loud or high pitched sounds gave rise to jagged shapes in her visual field and triggered bursts of pain in her forehead (Cytowic, 1989). But while a non-synesthete may not experience such extremes as a true synesthete, intense written description, particularly if it appeals to multiple senses, has the potential to be equally moving or distressing. "A man and a woman arrived together at night," does not have the same effect as something like Russian novelist Olga Grushin's saturated opener from *The Dream Life of Sukhanov:*

"Stop here," said Anatoly Pavlovich Sukhanov from the backseat, addressing the pair of suede gloves on the steering wheel.

The white-and-yellow columns outside his window ceased their tiresome flashing, began to slow down, and in another moment fell obediently into their assigned places. A pale orange tentacle of a nearby streetlamp pierced the plush darkness around him, and Nina, who had been silent the whole way, stirred as if waking.

"Already?" she said absently, glancing outside.

They were there. With a slight sigh, she searched for something in her purse, as she always did upon arrival. Sukhanov waited patiently while she flipped open a com- pact, balanced its small convex pool of glittering black- ness on her palm, slid a peach-colored pillar of lipstick out of the golden coils of its case, and proceeded to bend her face this way and that, trying to chase her reflection out of the shadows. (Grushin, 2007, p. 1)

The intensity of imagery produced in this scene is extraordinary. The author wields her words as a paintbrush, and they work in her favor to compose a vivid scene that continues to unfold with each syllable. This is further demonstration that the universally synesthetic quality of written language allows non-synesthetes to experience involuntary word and color associations, a characteristic of learning to read, basic Saussurean semiotics, and the plastic nature of the human brain.

Authors have taken advantage of this property for centuries. Descriptive literary works evoke senses and emotions alike, contributing to a greater narrative or storyline. This knowledge is similarly advantageous for the graphic designer working with text to communicate a message, be that a message delivered via high-visibility corporate branding or a quietly designed book. Though the path to true originality is fraught with precedents, effective creativity in design thrives when the designer can pinpoint the needs of an audience. Knowing how an audience will perceive a piece allows us to make creative and artistic decisions that promote an understanding of greater ideas in the text. Typography plays a major role in this goal, a fact I came to know firsthand as a graduate student in my first typeface design course. I was tasked with creating a text face in a style appropriate for an author of my choosing. With Russian thinker Fyodor Dostoevsky as my muse, I carefully considered his body of work while constructing my letterforms. I settled upon a serif face in the Old Style, alluding not only to his active writing period but also the darkly humanist themes that thread together his existentialist oeuvre. The sloping serifs signify heaviness and create a variable visual rhythm, while the low stroke contrast evokes literal and metaphorical darkness on the page (fig. 1). Each detail is a deliberate allusion to the broader context (in this case Dostoevsky's writing), subtly reinforcing a greater message. Without considering these possibilities, the design may fall flat; it will not live up to its full creative potential.

Though the appearance of words (particularly color adjectives) does not affect their synesthetic properties, the structure and formatting of letters, words, and sentences can make a world of difference in their perception and presentation. The term *typographic color* describes the density (or relative "blackness") of a block of text. There are many variables that contribute to typographic color, including choice of typeface, word spacing, letter spacing, leading (the space between lines of type), trim size (page dimensions), and text block dimensions.

The individual characteristics of specific typefaces are a starting point from which to adjust other typographic settings. Old style serif faces, for instance, have heavier serifs and lower stroke weight contrast than a transitional or modern typeface, making them appear darker on the page than other classifications even at the same point size (fig. 2). Of course, it depends on the desired appearance of

the text block; an old style face such as Caslon would likely require wider leading, more word spacing, and more letter spacing in order to achieve a lighter appearance. Baskerville, a transitional typeface, would not need as much space to attain a similar density because of its lighter stroke weight and higher stroke contrast thick to thin.

The subtle art of typography is about finding a balance between form and counterform, between positive and negative space. When setting long blocks of text, a designer does not manipulate the letterforms; she manipulates the space *around* them. A related, interesting optical phenomenon dealing with figure, ground, and contrast is the Hermann grid (fig. 3). Consisting of dark squares with equal space between rows and columns, the Hermann grid produces illusions of persistent dark spots at each intersection. These spots vanish when looking directly at each point. This is an example of lateral inhibition, a mechanism of our visual system in which the stimulation of neighboring cells decreases the original signal strength of a central cell (Wang, Hwang, & Lee, 2009). In the retina, the nerve-rich field in the back of the eye, the strength of any given signal is dependent on the triggered signals nearby. In the case of the Hermann grid, the intersections of the lines have four different directions of white to activate these additional cells, so they appear to darken with the subsequent decreased signal strength (Wang et al., 2009).

Though this effect can be reduced in intensity, it is difficult to manipulate the Hermann grid to be rid of the illusion altogether. Psychophysical researcher Lothar Spillman conducted a series of experiments in the early 1990s in which he tested variations on the grid and measured the physiological outcomes. Among other findings, his results suggest that the illusion is diminished (though still present) when the grid is presented diagonally (fig. 3). Spillman concludes that this is likely due to the orientation-sensitive lateral cells in the eye and visual cortex (Wang et al., 2009).

The Hermann grid uses simple squares and equal vertical and horizontal space to achieve its ever-present illusion. What if the grid were more complicated, made of multiple, irregular shapes set in evenly spaced rows— a text block? How does the same biological principle at work in the grid affect our perception of the darkness (or lightness) of type, and how does it influence our interpretation of typographic color?

These are questions I considered while drafting and designing the blackletter typeface Abenteuer. In lowercase, with its thick, vertically oriented stroke and regimented system of shapes, Abenteuer presents a highly rhythmic line of positive and negative shape interactions, particularly when tightly kerned (fig. 4). The variation in white space and the differing distances between solid strokes activate an uneven peripheral darkening of the negative shapes—the same effect of lateral inhibition we experience with regimented squares. This was achieved with careful consideration of form and counterform in the crafting of individual glyphs. Maintaining uniform angles, curves, and thicknesses from character to character ensured a geometric consistency reminiscent of the Hermann grid's rigid structure.

Though the blackletter is perhaps an atypical example pushed to an extreme—overly tight kerning, close leading with irregular forms and ornament— this phenomenon certainly exists with other text styles and settings. A similar observable result occurs with Univers, a more straightforward sans-serif typeface (fig. 5). Despite the relative ease of assigning numerical values to type size, word spacing, letter spacing, and leading, this simple biological occurrence plays an undeniable role in determining typographic color, regardless of the "actual" points and picas in the document.

As contemporary designers, we are accustomed to the sterility of the screen and the perfection that can be generated from our ever-advancing tools of the trade, but regardless of technology, we can never escape the influence of the physical world and our own biology. Written language, having been developed to communicate using fundamental sensory input and the processing ability of the brain, has taken on its own set of intrinsic characteristics. Its universally synesthetic quality grants it descriptive power unique unto itself, while what constitutes its proper formatting today has evolved based on those same biological limitations. When designers become aware of these involuntary effects, they better understand the processes at work within themselves and their audience, granting them yet another tool with which to communicate and strengthen their message. In this way, the consideration of science and biology allows for fresh associations and new conclusions between two

very different professions. The exposure to elements outside a designer's immediate field inspires expansive and lateral thinking, crossing into new and exciting territory—kindling the flame of creativity to a blaze of new approaches and ideas.

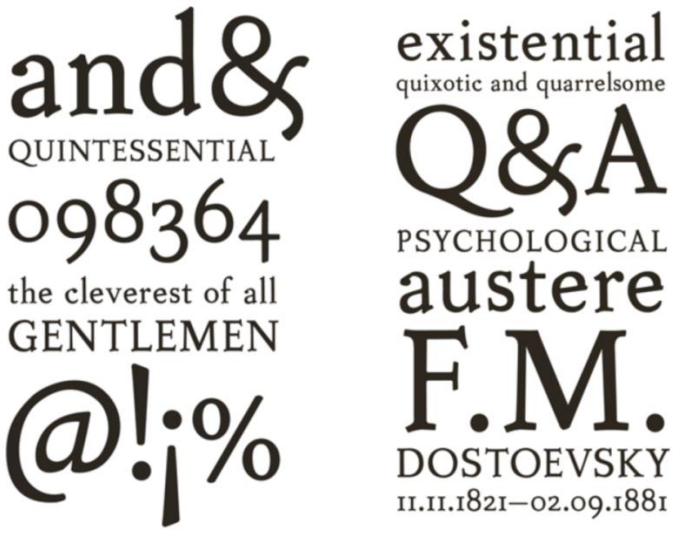

Figure 1. An allusive type specimen from the Dostoevsky-inspired typeface Raskol

Figure 2. Jenson (left), an old style face, has lower stroke contrast than transitional Baskerville (on right)

Figure 3. On right, the Hermann grid. The effect of the grid is diminished when tilted diagonally (left), indicating the orientation-sensitive cells in the eye.

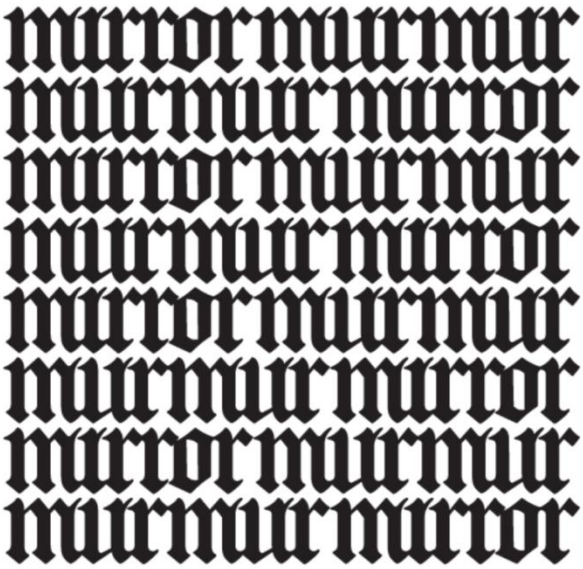

Figure 4. "Murmur" and "mirror," chosen for their uniform height, rhythm, and a juxtaposition of straight and curvilinear forms, in Abenteuer.

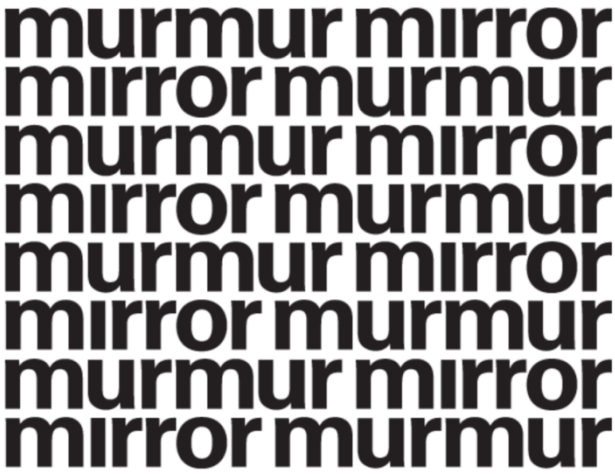

Figure 5. Univers LT Std Bold. The sans-serif typeface, with its relatively even stroke weight, produces a similar effect.

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