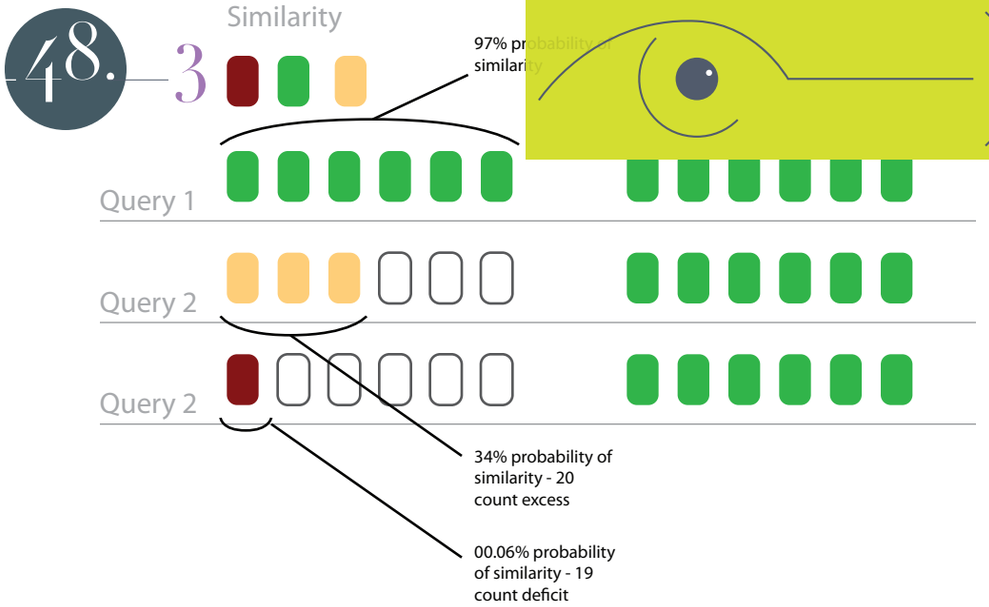
Visible Language

the journal of visual communication research

48. 3

November 2014



visualization logic

50% – 100% probability of similarity = green

5% – 50% probability of similarity = yellow

less than 5% probability of similarity = red

six boxes filled in proportion to show inter-hospital similarities
six boxes need to show probability over/under 50%
six boxes can be rapidly enumerated (in about 1 second)

A Statistical Approach for Visualizing the Quality of Multi-Hospital Data

Connolly et. al.

ISSN 0022-2224

education theory

design principle

drill

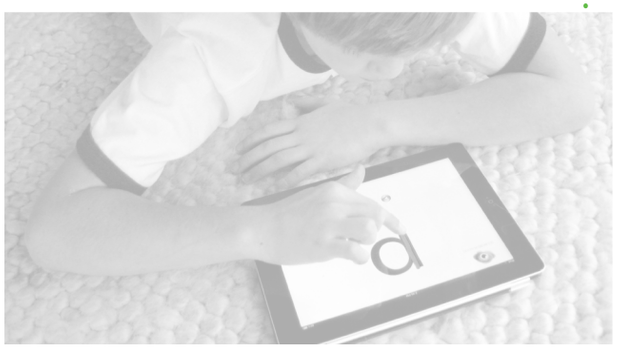
listen to sound

tactile

responsive

interaction

usability



universality

visibility

memorability

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mnemonics

first-sound

Linking Design Principles with Educational Research Theories to Teach Sound to Symbol Reading Correspondence with Multisensory Typea

Seward et. al.

individualized

evaluation

narrative

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improvisation

"Linear" by derek bealieu

improvisation

readings

Visual Improvisation: Cognition, Materiality, and Postlinguistic Visual Poetry

Mike Borkent

University of British Columbia

ABSTRACT

In this article, I present a framework for the analysis of postlinguistic visual poetry through a discussion of several works by Canadian poets derek beaulieu and Donato Mancini. This poetry eschews words to manipulate parts or hints of letters, exploring the minutiae of typewritten form for meaning construction. Drawing on recent work in cognitive science, I show how visual poems disrupt common understandings of language through its materiality, how the creators engage in improvisations around these understandings to develop the unexpected, and how the poetic artifacts prompt dynamic inferences and improvised understandings in readers. Meaningful understandings of the poems emerge especially from the development of relational understandings between fragments of letters through the perception of fictive motion and fictive change. I show how cognitive improvisation facilitates these perceptions and meaning construction in the contrastive styles of beaulieu's and Mancini's poems. I argue that improvisational cognitive processes on the part of both the writers and readers play a crucial role in how postlinguistic forms come to be meaningful within the context of bibliographic and material expectations.

KEYWORDS

cognitive poetics, visual poetry, improvisation, materiality, fictivity, asemic, postlinguistic

POSTLINGUISTIC VISUAL POETRY

Visual poetry, such as the following untitled poem by derek beaulieu (Figure 1; 2008, 48), foregrounds the materiality of written language through its forms and spaces of presentation, emphasizing contributions from both visual and verbal modes. As such, it engages with facets of bibliographic, pictorial, typographic, and inferred phonetic forms and conventions as elements of expression. While aspects of visual meaning generally contribute to formal choices in contemporary poetry, such as through line and stanza breaks, visual poetry utilizes the potential of these components extensively, making them essential to analysis rather than optional. It pushes beyond language's references or representations to draw on the materiality of writing itself, including its medially and technologically derived qualities. Visual poems must be seen to be understood.

FIGURE 1

untitled poem by derek beaulieu. Used with permission.

In this poem, for example, beaulieu manipulates the similar shapes of the letters 'a' and 'g' to develop a form like a looped or knotted rope. Overlaying and connecting the similar letters constructs an extended, visual rendition of the word 'gag.' The poem's cyclicality and inverted mirroring—a visual style commonly seen within beaulieu's book—seems to stop compositional expressivity by creating a Mobius strip out of language, effectively gagging written language through its own forms. The poem also makes a mockery of approaches to language that overlook the letters for the words, thereby also punning on the alternate meaning of 'gag' as a farcical joke. The otherwise blank page further emphasizes the singular word and its insular form, adding to the sense of binding and isolation. Here, the letters and their context enact the verbal content, while also poking at critical approaches that ignore their creative, material potential. This poem exemplifies the semantic and visual synergy employed in visual poetry to construct multiple levels of understanding.

Visual poetry's ancient history, which likely began with writing itself (Balan, 1999, 7), primarily involves the mimetic, imagistic orientations of words seen in shaped, pattern poems (see Higgins, 1987). The recent influence of the theory and practice of the European avant garde, in particular the visual and non-linear textual productions of Mallarmé's and Apollinaire's Imagism as well as Futurism, Dada-Surrealism, and Vorticism, widened the creative possibilities for visual-verbal expression (see Bohn, 1986; Drucker, 1996). This typographic and bibliographic expansion prompted and informed the "classical period" of visual poetry between 1955–1970, known as the International Concrete Poetry Movement, which continued to broaden the possibilities for relating and integrating form and meaning (Perloff, 1991, Scobie, 1984, 30-32; see Solt, 1969). Especially since the 1960s, visual poetry has had a strong presence in Canada (see Balan, 1999). Throughout this recent history, Johanna Drucker notes an ongoing trend, in

both Canada and abroad, towards "an intensification of hybrid syntheses of visual and verbal means" (1996, 57). This trend is particularly noticeable in the growing production of what I call postlinguistic visual poetry (e.g. see Hill & Vassilakis, 2012), which eschews words to manipulate parts or hints of letters, exploring the minutiae of written form.[1]

bpNichol, drawing on Michael Weaver, popularized the distinction between clean and dirty visual poetry (Emerson, 2011; Scobie, 1984, 35, 139). Clean poems visually mimic or enact the verbal content, such as in the case of shaped poems and many classical visual poems (see Higgins, 1987; Solt, 1969). Dirty poems, on the other hand, are "more interesting, and more supportive of contemplation, re-reading, or criticism" because they are "determined by structural principles, often abstract or arbitrary, which emerge from the visual or aural *material* of the words rather than from their expressive content" (Scobie, 1984, 35; see also Gross 1997). For example, beaulieu's "gag" poem might be considered an elegant clean poem, since it mimics or enacts the meaning of the word, placing the visual in service to the verbal. However, the lettristic connections between the letters, which visually support the synthesis of the two meanings of the word while elaborating its form, add dirty features as well. Furthermore, this is the only poem in beaulieu's book-length project that uses any recognizable words at all, with the remaining poems being non-semantic in focus. Perhaps we could infer that this is a poem that has stumbled across its linguistic element through structural affinities between the letters. This perceptible oscillation between clean and dirty designations in beaulieu's poem affirms Scobie's assertion that while useful for "describing tendencies ... it is unlikely that any given piece will fall *wholly* within one category" (43). Nonetheless, postlinguistic visual poems, such as the following poem by derek beaulieu (Figure 2: 2008, 85), and others by beaulieu and Donato Mancini discussed in this paper, represent the focused, materialist expressions of dirty visual poetry through their "anti-representationality and embrace of illegibility" (Emerson, 2011, 122). One might even consider postlinguistic poems—which I call poems that require the recognition of typographical linguistic features for interpretations while simultaneously refusing to use words—as embracing the dirtiest edge of the dichotomy, such that one might call them filthy, organic, sensuous. This filthy type of visual poetry disregards linguistic meaning while fostering alternative understandings of language, poetry, and print.

The postlinguistic poem by derek beaulieu in Figure 2, for example, seems to represent letters moving actively around the page—interacting, reconfiguring, and translating each other though their alternative forms, orientations, and possible sound(ing) lines. It might be argued that the poem represents the origin of language through an analogy to the 'big bang,' or perhaps a transformational, pre-linguistic confusion of sounds, or a playful rupturing of bibliographic expectations to construct depth out of linearity (and so on). Such poems offer challenges to how

1
While beaulieu (2006a) describes poems like the ones discussed in this article as "non-semantic," this elides the meaningful qualities of the poems prompted by but not denoted by the letters. Similarly, these poems seem to qualify as "asemic writing" to some extent, but their employment of the Roman alphabet constrains them beyond the more pluralistic and gestural qualities typically ascribed to asemic writings. To some degree we could call them *asemic typings* instead, but the term *postlinguistic* is purposeful. This term seeks to foreground the lettristic, typographical heritage that these visual poems both build upon and thwart. Without this sense of print literacy, such poems lose their potency.

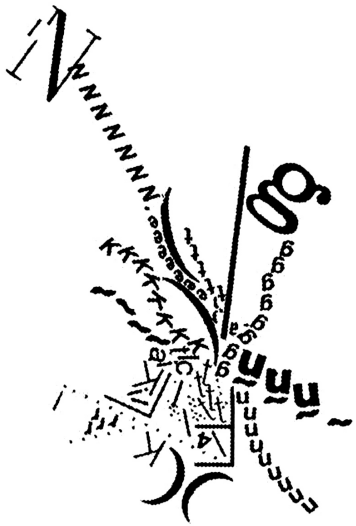

FIGURE 2

untitled poem by derek beaulieu. Used with permission.

critics describe and interpret them. Visual poetry, especially more recently, foregrounds crucial questions surrounding the interwoven notions of perception, representation, and meaning, and encourages readers "to develop a more flexible and creative attitude toward communication and a dynamic sensibility regarding perceptual experience" (Swiss, 1976, 46). Visual poetry manipulates and appropriates, as well as erodes and undermines, many assumptions about language to promote a process of *thinking through* the materiality of written language itself in both its visual and verbal modes of signification. As Sabine Gross (1997) shows, such doubling of sign functions significantly increases the cognitive work (and pleasure) of readers as they attempt to interpret the poems. For instance, as we saw with the gag poem, the form does not simply mimic the verbal cue but construes and expands its meanings as well. In these works "metaphor has become a tool of both form and content" (Beiman, 1974, 200) through which "'meaning' … is multiplied" (221). derek beaulieu takes this idea further to suggest that with postlinguistic visual poetry "the best we can strive for are momentary eruptions of non-meaning which are then co-opted back into representation by the very act of identification, pointing & naming" (2006, 84). Considering such poems, a series of questions emerge: How does poetic metaphoricity emerge out of perceptual phenomena? How does contemplation lead to multiplication? What do postlinguistic poems identify, point to, and name? How do readers enfold ruptures back into coherent meanings? How do readers, even of a seemingly straightforward poem like beaulieu's elegant "gag" above, make dynamic inferences that multiply understandings from static, lettristic rubble?

To elaborate on how visual poetry prompts this range of different thought processes, I draw on recent research into image and text comprehension in cognitive science to suggest cognitive processes at work in reader-viewers as they interact with the poems. This research reveals, (1) how visual poetry disrupts a common understanding of language, (2) how beaulieu and Mancini engage with these assumptions through a process of textual improvisation in order to construct the unexpected, and (3) how their improvisational artifacts composed of static representations prompt dynamic inferences and propositional understandings in readers in a type of improvisation as well.

The theoretical approach this paper outlines locates visible language and print culture as part of a cognitive and

intersubjective network of mind, body, and environment, and as such it stays close to the cognitive literature. Methodologically, it both describes the poetic artifacts and their production (much like an art or new historical approach), while also paying particular attention to how meaning is produced through responses to the materiality of language, in a way analogous to a materialist and poststructurally-inflected reader-response theory. In this way, I blend the classic tension between art historical descriptions of materials to more nuanced engagements with the phenomenological processes of seeing, seeing-in, and seeing-as (see Newall 2011); and in literary terms, between reference and free play. By locating key features of the poetic texts and their correlated cognitive responses, I show how knowledge of cognition helps direct analyses of these difficult postlinguistic texts.

RUPTURED METAPHORS

The early cognitive linguist Michael Reddy (1979) identifies the most common folk theory of language as the *conduit metaphor.* In this view—which Barbara Dancygier calls the "conduit fallacy" (2012, 203-04)—language users conceive of words as objects or containers (the form) into which communicators place meanings (the content) and move it seamlessly to a recipient for unpacking. This metaphor informs phrases like "do you get what I'm saying?"—which queries the transference and unpacking process—as well as phrases like "building on what you said"—which views words as objects that support further conceptual development. Most scholars would likely find this rigid model of language troubling for a number of good reasons, especially, as Reddy observes, for its decontextualization of language use and its assumed or purported clarity of reference. However, we remain influenced and at times hampered by this folk ideology which privileges abstract linguistic meaning over the means of its relation and other non-linguistic cues that accompany it. For instance, the paucity of attention to visual form in literary studies affirms writing as solely verbal rather than as a hybrid of visual and verbal modes.[2] Visual poetry, as the examples above show, actively plays with and disrupts this metaphorical belief by engaging with the materiality of visible language, foregrounding its surfaces, qualities, and configurations to prompt emergent, synthetic understandings. With visual poems, one cannot ignore the container for its contents, as each play a role in poetic meaning.

As I have discussed elsewhere regarding Canadian poet bpNichol (Borkent 2010), clean(er) visual poetry can use sparse verbal and visual cues to construct complex meanings, presenting only "illusions of simplicity" (to recycle the title of that paper again). That analysis attests to the cross-modal construction of understanding prompted by texts that make distinct verbal and visual contributions. derek beaulieu's "gag" poem works similarly in this vein. These poems illustrate the productivity

2
The preference for verbal over visual modes reflects a number of fallacies surrounding modalities, especially the fear of visual hegemony, that support a monomodal rather than "hybrid" perspective (see Mitchell (2002), especially 174-76). This paper offers one such hybrid approach.

of creative, manipulative engagements with the materiality of letters and words by reorienting and drawing attention to the metaphorical container and by foregrounding synergies between visual and verbal representations and conceptualizations. Nevertheless, postlinguistic visual poems, such as in Figure 2, refuse to use words yet continue to explore expressivity and poeticity. These poems destroy the metaphorical container in order to reconfigure how we conceive of it and its production. But how do such meaningful reconfigurations come about?

COGNITION AND IMPROVISATION

Recent research in the cognitive sciences[3] shows a strong grounding of conceptualization in perceptual experiences across and between the senses through the *dynamical systems* of multimodal cognition (see Barsalou, 1999; Gibbs, 2006). This approach affirms a perspective of perception and cognition that emphasizes its embodiment, through which bodily interactions with specific environments (sensorimotor experiences) inform conceptualization in ways that blur the boundaries between subject and object (Hutchins 2010). A growing body of analysis on the use and comprehension of language, images, and other communicative modes has established this as a central feature of cognition and meaning (see Gibbs, 2006; Hutchins, 2010; Johnson, 2007). This research identifies a web of connections between concrete, sensorimotor experiences, developed out of organism-environment interactions and self-reflection, and their various abstract and creative extensions (and back again). This involves repurposing perceptual mechanisms for conceptual understanding and creativity, in particular interweaving perceptual phenomena such as gestalt understandings of disparate objects, force dynamics, and the affordances––the "possibilities for interaction"––with things (Johnson, 2007, 46). These imaginative processes within perception illustrate how meaning arises as an interaction between perception and abstract cognition rather than a simple effect of "pure" reception. Construing meaning in this way unravels the containment model of the conduit metaphor and places an emphasis on dynamic interactions between people, things, and environments, with and through different communicative modes. Thus, print technologies become a part of this perceptual-conceptual dynamic as an environment for creative interaction with things (in a sense, the page becomes a stage). These medial interactions can be purposeful or improvisational, with postlinguistic poems placing an emphasis on the latter.

I use *improvisation* in a different sense than the more commonly jazz-focused usage, in a way that correlates to the avant garde textual history of visual and conceptual poetry, particularly seen in many Dadaist methods as well as more recently in the work of creators like Brion Gysin and John Cage and many other experimentalists. I consider

3
By recent research, I refer to "2nd generation" cognitive science. 1st generation cognitive science, informed in language studies by such figures as Chomsky and Pinker, espouses an amodal, disembodied, symbolic, modular, and computational view of mind. In contrast, 2nd generation research describes the embodied, multimodal, networked, and grounded views of mind used in this paper (Barsalou 1999). See Gibbs (2006) for a thorough synthesis of the diverse research areas that affirm this position.

improvisation to be a particular creative practice or artistic stance towards a medium and its conventions. This stance centers on eschewing or disarming overt authorial intentionality in order to respond in the moment to the materials of the artistic environment. Like John Cage, I "[embrace] one rarely achieved and often illusive etymological meaning of improvisation: to do something unforeseeable" (Feisst, 2009, 49). It is a "search for the encounter of an unexpected experience or revelation" (49).

In his discussion of improvisation, cognitive psychologist Raymond Gibbs suggests that

> skilled performance is not generated from a prior mental decision to act in a particular way that is independent of . . . behavior. Instead, skilled human action may arise from how the individual's frame of mind automatically selects a subset of behaviors . . . from the unlimited alternatives within the self-organized constraint space that is defined by person-environment interactions. (2006, 77)

The improvisational stance centres on this confluence of skilled yet "automatic" (i.e. unconscious) and dynamic responsive behaviour that can apply to any medium and its modes of representation. This stance prompts a creative process that constructs an improvisational product of sorts—the trace of an anti-authorial, materialistic engagement—for instance, the jazz performance or the textual artifact. Thus, the postlinguistic visual poem reflects a cumulative lettristic trace of the real time, improvisational interaction of the writer with the materials of textual existence including the letters, the paper (both its size and weight), bindings (or lack there of), and the various technologies of print production (pens, stamps, typewriters, photocopiers, computers, etc.). Unlike musical improvisation, which is responded to in the instance of performance through various instruments, textual improvisation leaves a specter of itself for interpretation, one that reflects its means of production. For visual poetry, the print medium limits the materials of improvisation through variously related print technologies, while providing the means to showcase them. Likewise, cultural expectations, linguistic and artistic scripts, and so forth, influence conventions and readerly expectations, which the poet engages as part of the literary environment. Of course, as artifacts rather than performances, poems can be returned to again and again for further scrutiny without re-mediation, which sustains Scobie's notion of dirty visual poetry prompting contemplation and criticism.

IMPROVISATIONAL CREATION

derek beaulieu's and Donato Mancini's compositional methods differ in dramatic ways, but they both engage with and reconceptualise typographical forms by improvising responses to the forms' affordances—their possibilities for interaction beyond their conventional uses. The consistent style of the

book-length projects of both authors focused on in this paper creatively extrapolates beyond the traditional uses, roles, or values of letters by interacting with them as objects or things on the page. Engaging the affordances of things involves disintegrating previous understandings of the thing in order to select, alter, and reintegrate its elements for different purposes. An example of affordances in action would be the use of a large book as a doorstop, re-conceptualizing and valuing it for its weight and shape rather than its contents. As Figure 2 illustrates, postlinguistic visual poems engage with letters to share a similar, affordance-based, improvisational logic, using type while reconfiguring or ignoring most of its conventions. This creative approach suggests to viewers alternative relations with letters beyond their uses as the building blocks of words, acronyms, and other symbols within specific typographic and bibliographic environments. beaulieu's and Mancini's improvisation through the materiality of specific letters foregrounds and develops the expressive quality of letters that un-forms and informs both the letters themselves and readerly expectations of them, in particular deconstructing and re-construing the conduit metaphor. Through this creative process, the poets begin to map out new, meaningful perceptions of language against a complex bibliographic, pictographic, and typographic history.

In his book *chains* (2008), as well as in other projects, derek beaulieu uses sets of typefaces on Letraset dry-transfer sheets—a lettering technology once used by drafts-people and designers to avoid the idiosyncrasies and errors of hand-drawn letters[4]—to create typographic consistency between individual letters and within poems. As seen above in his "gag" poem, this consistency allows letters to slide into each other, to overlap, and to, in a sense, respond to each other since they replicate each other's forms either completely or by "mimicking" aspects, such as shared, font-specific features like serif shapes (terminals), loops, and angles of axes. beaulieu observes that in composing his postlinguistic poems he generally attempts to respond to a sense of non-linguistic connections or responsivity between letters, playing letterforms off of and through each other (beaulieu, 2009).[5] beaulieu plays with orientations and relations of letters to decompose and recompose bibliographic assumptions surrounding type and visible language. This free-flowing compositional method removes most notions of authorial intentionality since beaulieu is not attempting to convey anything specific, but fosters, as a creative organism in a textual environment, a sensuous response to letters as meaningful, constructive forms unto themselves.

Unlike beaulieu's archaic lettering technology, Donato Mancini, in his book *Æthel*[6] (2007), engages with digital fonts by "butchering them with the virtual razorblade" of image manipulation software and "Frankensteining them back together until the shapes on [his] screen looking back at [him are] unrecognisable as products of [his] own imagination" (2009, 26). Unlike beaulieu's typeface constraints (ones available on archaic Lettraset sheets), Mancini engages with a wide variety

4
While creating consistency here, elsewhere beaulieu experiments with incomplete or manipulated transfers (e.g. see *Fractal Economies* (2006b)), along with other textual materialities tied to production technologies. A more detailed discussion of this range of approaches, as well as his other writings, exceeds the limits of this paper.

5
Similarly, Judith Copithorne, another important Canadian visual poet who creates postlinguistic visual poems, notes that for her composition method she is "working in a more physical manner with the actual visual reactions to the various physical attributes of the piece" (Barwin and Copithorne, 2013, n.p.).

6
As with beaulieu, Mancini's diverse creative output exceeds the limits and focus of this paper; therefore, I have limited myself to selections from one book of similarly styled visual poems.

of written language forms, including from Black letter (Gothic) to contemporary fonts as well as alphabets ranging from ASL hand signs to a range of other, non-Western scripts. (To ease comparisons between beaulieu's and Mancini's poems, I focus on poems that appear to be constructed out of the Roman alphabet.) Similar to beaulieu, Mancini asserts that a process of open, responsive, lettristic engagement produces poetry in which "there's little invention; there's inventive recombination. The only constraint was that [he] wasn't allowed to draw new lines. All of the lines come from lines already present in the letterforms." As such "Intentionality ... was severely frustrated" (26). This lack of conscious intention again contributes to an improvisational creative process, constrained by the affordances of lettristic forms but also developing and reconstructing through and beyond these understood limitations. While beaulieu plays with the affordances of whole letters in relation to bibliographic norms, Mancini decomposes the letters themselves, recomposing or reconstituting typography at a different level.

The removal of forethought, of intended directionality and focus other than responding to the affordances of material forms themselves, reveals the improvisational nature of beaulieu's and Mancini's compositional processes. This characteristic resounds from their poetry: one reviewer even draws analogies between beaulieu's style and Miles Davis' ability to "[tap] the vein of jazz" (qtd. in the author note of beaulieu (2008). See also Mancini (2009, 25)). Figure 2 reflects this understanding through its explosion of letters and their inferred sounds. For postlinguistic poetry, typographic and bibliographic conventions, as well as expectations regarding specific, material engagements with letters and page space, contribute crucially to their composition and reception. Letters, or aspects thereof, in conjunction with the dearth of words, straight lines, spacing, "proper" orientations, and margins, all contribute to the readerly experience of rupture and play. Poetic alternativity makes the lettristic lettristic improvisations salient and novel. Through this improvisational engagement, beaulieu and Mancini produce poetry that points "to and away from multiple shifting clouds of meanings and constructions" (beaulieu, 2006a, 82). These poems "[challenge] the status quo of poetry and of the politics of language" (90) by denouncing expectations prescribed by the conduit metaphor and bibliographic history, by delighting in the visuality of written language, and by exploring meanings beyond the purported containment of the word.

COGNITION, FICTIVITY, AND IMPROVISATIONAL READING

Through their abstract representation of multiplicity and indeterminacy, and largely the lack of linguistic specificity (Mancini does add titles, which I address later), the visual poems of beaulieu and Mancini invite a creative reading process that navigates through this apparently nonsensical openness

and rupture. Since postlinguistic visual poems offer no words, they seem restricted by their own materiality and visuality, divorced from conceptual or propositional meaning. While we can articulate how they break from typographic conventions, as well as draw on the avant garde tradition of typographical innovation and disruption, to articulate how the forms prompt new understandings remains difficult. To come to beaulieu's impressionistic sense of "shifting clouds of meaning" from letters fixed to the page, readers develop a dynamic understanding of the text out of its static forms.

To move from stasis to dynamism, from abstract form to meaning again, readers likely improvise beyond purely linguistic or symbolic understandings by engaging with the very affordances that the poets initially responded to to construct the poems. By reanimating senses of the compositional manipulations and disruptions of various forms, readers infer action from static things and construct interpretations from these dynamic elements. In short, this poetry impels a materially contiguous and contingent, rather than symbolically and abstractly, derived understanding that requires a multimodal approach to unpack.

The same embodied cognitive abilities that foster textual improvisation in the making of postlinguistic poetry also support the dynamic, interpretive processes of viewers of these poems. The pervasive harnessing of embodied, sensuous, and emotional experiences to develop elaborate, novel, fictive, alternative, and abstract constructions relies on the ability to mentally distance or attenuate our cognitive processes and then reanimate bodily knowledge through a process called *mental simulation* (Langacker, 2008, 524-537; Bergen, 2012; Gibbs, 2006; Matlock, 2004). This process of reanimation facilitates novel and/or fictive connections and inferences about experiences and things, from basic understandings of perception to elaborate metaphorical abstractions in language and other modes of expression. The attenuation of mental processes from physical ones allows for discrepancies between experiential knowledge and mental interpretations or connections. Leonard Talmy (1996), in his influential discussion of fictivity and our "cognitive bias towards dynamism" (213), focuses particularly on "nonveridical phenomena" such as "linguistic instances that depict motion…[and] visual instances in which one perceives motion *with no physical occurrence*" (211, emphasis mine); such an instance occurs when describing or perceiving a fence as running across a field. Mental simulation interprets these phenomena through inferential processes regarding objects, agents, perspectives, and means of perception and interaction (see Gibbs and Matlock 2008), with fictive constructions fostering more dramatic interpretations than non-fictive constructions (Matlock 2004). A closer look at two broad types of fictivity adds to the discussion of visual poetry by showing the significance of these processes to emergent, dynamic understandings of static representations, such as the cyclical and explosive inferences ascribed to the previous poems.

One notable embodied experience of fictivity

discussed by Ronald Langacker (2008), *fictive change*, denotes the subjective construal of something in terms of an alternate state of being. For instance, conceptualizing a "broken line" involves an archetypal line which breaks in the process of being represented on the page as a series of dashes (see Langacker, 2008, 530); by simulating the breaking of a whole line to interpret the dashes, readers conceive of a state prior to representation. In Figure 2 (the "big bang" poem), the top left N is likely simulated as having broken or become altered in the processes of representation, as shown in Figure 3, rather than simply being interpreted as its own unique form. Other change-of-state expressions involve similar conceptual processes such that the negated state always informs conceptualizations, infusing the static representation with a dynamic, transformational shadow. For instance, beaulieu's "gag" poem maintains the sense of the regular spelling of the term; therefore, the extended body of the poem prompts a sense of fictive change that extends the word in order to bind it. This inferred change-of-state construes the extensive looping of the word as a propositional understanding, critically mocking notions of linguistic determinacy through lettristic elaborations or transformations of the constraints.

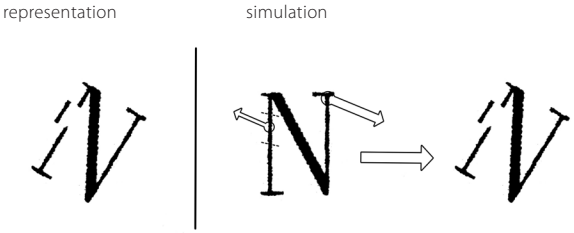

FIGURE 3

Example of fictive change simulation for top-most letter in Figure 2.

A related dynamic inference from static representations is *fictive motion* (see Langacker, 2008; Talmy, 1996). Derived from embodied perceptual cues of scanning an object or sequence, fictive motion occurs when readers or viewers conceptualize static objects as mobile, such as in understanding that a line of static dots *runs* across a page. This conceptualization involves inferences about trajectories and relations between static elements.[8] In terms of visual poetry, a repeated form, such as the various sequences of letters in Figure 2, can be construed as a single form glimpsed moving repeatedly through time and space, thereby prompting a sense of fictive motion paths across the page, such as indicated by the arrows in Figure 4. (Thus fictive motion motivated the readings of letters *exploding out* or of letters *moving through* the confusing mass at the centre.) Similarly, a homogenous, circular form, such as the first "gag" poem, might be construed as actively and interminably redirecting readers as we scan it, making it veridically static while feeling fictively dynamic. Fictive motion reveals the locus of that infinite looping that gags language and constructs understanding through perception. Articulating this dynamicity constructed through the scanning and reanimation of static representations—which derives from an embodied engagement with textual and imagistic space, objects, and actions—clarifies inferences made of visual poems that extend well beyond their forms.

8
Talmy (1996) describes multiple types of fictive motion paths. Here I only focus on the basic principle, which sufficiently covers my aims. Elsewhere (Borkent 2010), I have shown how two specific types of fictive motion path reveal poetic transformation in semantically-informed visual poems by bpNichol.

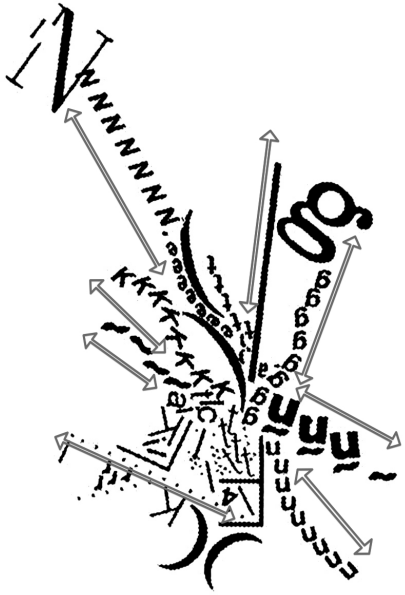

FIGURE 4

Possible fictive motion paths (arrows), correlating to groups of letters and punctuation, superimposed on Figure 2. Poem altered with permission.

BEAULIEU'S MACHINIC DISRUPTIONS

A glance at the earlier visual poems in derek beaulieu's book, *chains* (2008), reveals clear typographic control through limits on the size and number of letters used, large empty margins, and an overall repetitious or reflective pattern that seems to dictate their form (the "gag" poem, Figure 1, comes from this section). Rather than a negative criticism of these poems or an indictment of improvisation, this control reveals a creative engagement with the affordances of typography within some bibliographic constraints that sustain the perceptual and conceptual complexity within these poems. Poems, like the explosion of Figure 2, come and seem to break these limits later in the book, transforming the entire page into an active space of dynamic interaction. Such poems in particular, including the following one (Figure 5: beaulieu, 2008, 84), prompt improvisational engagements that move from dynamic creation to static artifact and on to dynamic understandings and interpretations.

The dynamic inferences of this untitled poem exhibit both fictive change and fictive motion. At first glance, the poem appears as a near-vertical line of "l"s and a perpendicular mass of letters on either side of it. The poem transforms into a scene of dynamic interaction through the mental reanimation of the letterforms and their relational qualities. The repetition of the "l"s vertically creates a slightly fragmented visual barrier that replicates the example of fictive change—the broken line—mentioned above, and which bifurcates the page into two distinct spaces.

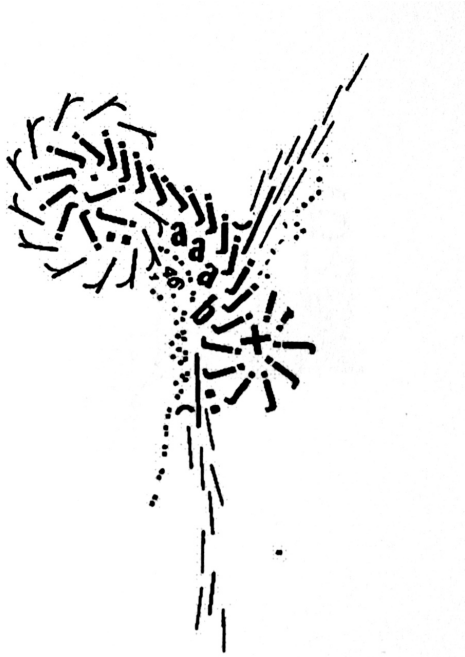

FIGURE 5

untitled poem by derek beaulieu. Used with permission.

A series of dots that run down the right side transfer to the left at the point when a series of "j"s breaches the divide; this prompts an instance of fictive motion, with the dots construed as one or just a few dots moving down the page over time. Because the line of "l"s buckles in the middle, the poem also prompts the inference of force dynamics, with the "j"s, through fictive motion, pushing upwards and through the line, pushing or drawing the dots through in the direction of force. This point of rupture couples the cases of fictive motion and fictive change, constructing an interactive scene on the page-stage through embodied simulation.

The circular form of the "j"s on the right has an "x" in the middle that suggests a hub around which they spin. The "j"s, whose dots point into the center of the wheel, fictively spin and fling through the barrier, inverting their orientations as they enter the new space. Then they rotate in the other direction, dots out, without a notable axis, and with a growing number of new forms of "r"s burgeoning out around them. Dots also fall below. Notably, the forms of the "j"s mimic through inversion the "r"s. Perhaps this indicates a transformation, a fictive change, of the "j"s in moving across the barrier, rather than simply the presence of a different letter on that side. The dots represent the part of the "j" that keeps it from inverting into an "r," and their removal supports the lettristic mimicry and sense of transformation.

The poem, as I have described it, focuses on the breaking of a barrier and the transformation of the "j"s into "r"s. In light of this, we might conceive of the liminal symbols caught in the breach—the few "a"s, a "b," and the number "46"—as the broken and bent bodies of "j"s sacrificed in the rupturing of the barrier, or as other letters that tried to cross and failed. One can speculate further here, but any "reading" ought to examine the affordances and fictive simulations that connect these forms and which motivate interpretations.[9] However, a second facet of embodied experience, of the readerly organism's environment, supports the leap from form (which I have already shown to be dynamic and meaningful) to more elaborate, poetic understandings.

Letters, not just abstract forms, make up these poems, which places these works into a typographic, bibliographic, literary, and visual history, including the pervasive conduit metaphor. Since cultural and social conventions and expressions inform embodied, felt experiences, they affect interpretative processes prompted by these works. Thus, formal

9
Other interpretations of this poem surely exist, such as of the form bursting forth like a fungus rupturing the bark of a tree or like a plant growing out of an embankment, drawing largely on the same fictive changes and motions discussed above but adding another layer of inference based on these forms. My reading lays the groundwork for these others.

inferences will vary between readers, based on differences in experiences and background knowledge, including language type (Bergen 2012). Through this situating of embodied cognition, the previous spatial reading now extends into a poetic reading of the grapheme, of the "inarticulate mark" (quoted in beaulieu, 2006a, 80), and the specific visible language that informs it. By elaborating on readerly expectations of common typographic forms, a possible interpretation of the poem could be that the wheel of machinic language breaks through a perceptual barrier to birth new forms that are free from mechanization (in a way making a mockery of moveable type through its very movability). Alternatively, machinic language breaks down in engaging a new experiential space that refuses it as it is and re-animates it in new forms. In either sense, the deconstructed containment of language gives rise to creativity by trespassing into new arenas and responding to them, de-mechanizing or refusing expected linguistic representation. Combining fictive dynamics of forms with experience invokes an understanding of the poem as a diagram of a theory of language, in which users break beyond the confines of the conduit metaphor to revel in embodied forces and experiences at work within representative modes and the medium.

Furthermore, through its reliance upon letters, beaulieu's poem draws on the domain of literary history, in terms of both production and reception. The repetition of letters creates a visual sense of rhyme and rhythm and, yet, refuses symbolic communication, forcing a poetic sensibility onto the raw materials of written language without determining what that sensibility might say. Nonetheless, the materials of the poem suggest a dramatic interaction between the machinic qualities of letterforms as they move through different spaces. From the perspective of an embodied reading, it focuses this energy on the reanimation and alteration of letters, thereby revitalizing the poetic eye and its graphemic extensions prior to articulation, injecting the dynamicity of the body into typographic space, opening up new perceptions of writing. The poem gestures through postlinguistic language toward a poetic, altered future, offering, in a sense, a poetic manifesto to transform type. By reconstructing typographic codes while keeping recognizable, unaltered letters, beaulieu's poem prompts an improvisational reading, fostering a sense of creative, future expansions extending from the present.

MANCINI'S SCULPTED LETTERS

Donato Mancini's poems in his book, *Æthel* (2007), also elicit improvisational readings but through striking stylistic differences. In contrast to beaulieu's hard, machinic Lettraset poems which compose new forms out of old, overlooked ones, Mancini's poems, such as "The Jazzercize Dance of Hope" (Figure 6: n.p.), decompose and recompose the letters themselves through digital manipulation, leaving glimpses of their former selves. Nonetheless,

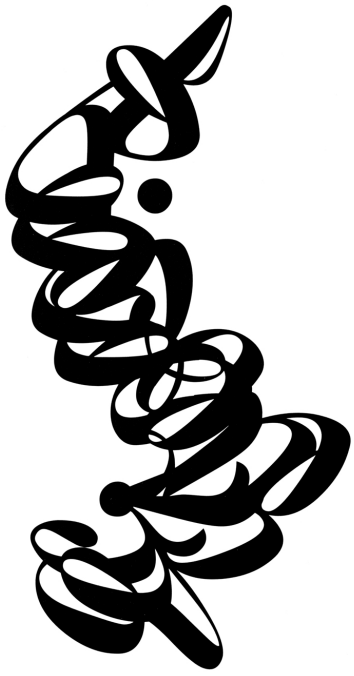

FIGURE 6

"The Jazzercize Dance of Hope" by Donato Mancini. Used with permission.

Mancini's works also elicit fictive motion and fictive change. While we cannot trace exact letters in space, the interconnected, recognizable aspects of decomposed letters (such as calligraphic stems, loops, and dots) and the overall twisted form lend it an organicism in two ways. First, the reader infers, through simulation, the authorial hand that carves up letters (rather than places them, like beaulieu) to construct the poem, exemplifying fictive change (as was shown in Figure 3). The reader also reanimates the represented forms by scanning them, interpreting them as fictive change or motion. Furthermore, this poem, located on the right-hand page, faces its title from across the spine of the book, prompting a perceptual shift across the fold to focus on it. This break between title and figure adds to inferences about its fictive activeness: in a sense, the poem becomes dislocated, quite literally, from its title and is dancing across and off the page.

The title's location and content also adds to the poem's interpretation by directing inferences about the poem towards the specific movements and roles of dance. As Mancini notes, his titles exploit experiential links and categories which "[open] a set of associative paths that determine multiple potential readings. 'Free', maybe, but finite" (2009, 29). A title does not delimit a specific reading, but rather introduces a complicating, constructional variable that lends directionality to improvisational interpretative processes.

This titular directionality prompts at least two possible routes for mental reanimation that derive from inferences about different perspectives on the poem and their types of associated fictivity. The first option sees this representation as a lone (I think feminine) figure moving upright through space as a (perhaps Flamenco) dancer, her arm outstretched above the dot of her head, her hips jutting to the right, and her dress swirling at the bottom. From this perspective, the Frankensteined letters become the energetic dance of the woman moving across the page-stage. The letter-figure fosters the reconceptualization of language into a linguistically nonsensical yet quasi-representational, imagistic form that reflects the health and creativity of "jazzercize." Through the openness and playfulness of an *almost* signifying act, it reveals the hopefulness behind expressivity as well. The fictive motion attributed to the form, motivated from experiential, embodied knowledge of dance coupled to the scanning of the undulating shapes, prompts this sense of health, creativity, and hope, promoting a view of the nonsensical as a beneficial and dynamic state for language.

However, while maintaining the perceptual and conceptual parameters of the dance, we might also construe the poem as a diagram of the foot patterns of an actual dance, as one might find in a dance handbook, viewing the page-stage from above. In this case, the shifting forms direct the future actions of dancers as they swirl across the dance-floor. The poem, from this aerial perspective, prompts a sense of fictive motion, since we can conceive of it as a sequential enactment by a single figure over time. At the same time, it also prompts fictive change, as the letterforms posit a fictive state of (altered) being. This still carries the hallmarks of the previous reading—health, creativity, hope—but revokes its fictive performativity through its futurity (perhaps the very definition of hope for a future performance). In this reading, the poem becomes a manifesto for a free typography, in a sense calling for an revolutionary, lettristic dance rather than allowing it on the page, diagramming a hoped for future state for type through a static present.

In both of these readings, the readerly activation of the forms as a dynamic performance or diagram becomes particularly meaningful through the directions of the title. While the form certainly suggests dance-like and energetic qualities, the title specifies ways of conceptualizing it and, to a degree, its affective calibre. At the same time, the title can hardly be taken at face value—just like the poem—in particular regarding jazzercise, a hybrid exercise-dance regime often characterized as kitschy and lacking the gracefulness of dance. The simultaneous juxtaposition and redundancy of combining "jazzercise" with "dance" prompts an ironic or facetious tone, which undermines any sense of blithe hopefulness. The dynamic mental performance of the representation enacts a sense of hopeful health on the page as we read, but the title both affirms and denies it. This duplicity, conferred as well through the conflicting and irreconcilable perspectives upon the poem itself (present/future, horizontal/aerial)—reminiscent of the classic examples of perceptual illusion like the duck-rabbit, first employed for psychological studies by Joseph Jastrow (Figure 7: 1899, 312)—adds a self-reflexive and self-effacing quality, emphasizing the representational fluidity within modalities. While the poem might seem to envision a typographic revolution through the butchered, dancing letters, expressing vitality outside of the constraints of the conduit metaphor, its conflicting compositional qualities, especially prompted by the directive framing of the title, also suggest a naiveté to the hope of typographic rebirth.

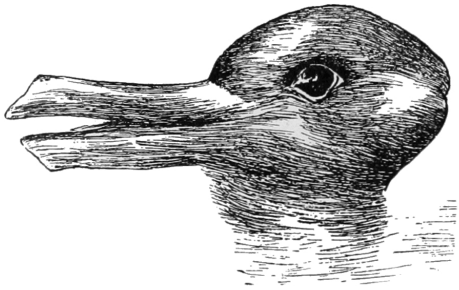

FIGURE 7

Joseph Jastrow's original duck-rabbit illusion illustration (1899, 312). Public domain.

Another poem by Donato Mancini, "Literature Prefers Metaphor" (Figure 8: 2007, n.p.), also combines conflicting lettristic qualities and layers to prompt conceptual depth. Two formal features suggest metaphoricity, even without the title—making the title less directive and more ekphrastic than the previous example. At first glance, the mutilated, black letterforms prompt similar inferences of fictive change as in his previous poem, through which lettristic forbearers haunt the poem. However, within this mixed form, new letter-like elements, especially tails and serifs, glint out of the internal white space as well. The co-presence of black and white letterforms constructs a bistable, metaphor-like relationship between two incompatible elements. The fictive motion prompted by scanning, reminiscent of derek beaulieu's cyclical "gag" poem, suggests a second metaphoric quality. Here, the looping qualities of the form mean that we likely cycle around the bends, folds, and junctures of the poem, scanning for a beginning or an end and for a point of recognition to offer coherence or intelligibility to these haunted forms. Instead, we remain caught in a perceptual tension between recognition and bafflement. Metaphorically speaking, this poem holds us in a state of excitation between a tradition of expressivity and its manipulative deconstruction.

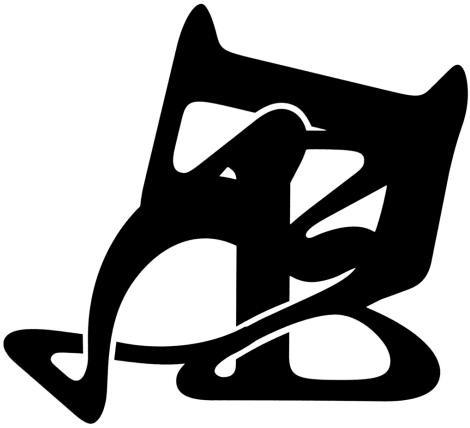

FIGURE 8

"Literature Prefers Metaphor" by Donato Mancini. Used with permission..

In the reading of the opening poem by derek beaulieu, the formal cyclicality prompted the gagging of language itself, in essence stopping up the conduit metaphor. Coming almost full circle, this poem actively and interminably cycles and transforms perceptions of language. While beaulieu's poem worked paradoxically through imagistic and verbal elements to become perceptually mobile while stifling linguistic activity, this poem's cyclical energy becomes the locus of literary and figurative productivity. As the poem's title (somewhat facetiously) suggests, the preference for metaphor—for interpretive layers, difficulties, and transformations—drives literary creativity. The poem enacts this understanding through the lack of words and the perception of fictive motion and fictive change; through improvisational engagements with recomposed typographic forms, it offers an interpretive structure that moves from linguistic bafflement to a sense of creative energy that affirms its ekphrastic title. Here, the conduit is multiplied rather than stopped.

POSTLINGUISTIC VISUAL POETRY AND IMPROVISATION

Postlinguistic visual poems, such as those by the Canadian visual poets derek beaulieu and Donato Mancini discussed here, present a decisive challenge to critical models that begin with linguistic and propositional views of meaning. A dynamic, embodied approach to meaning facilitates articulations of how forms and their connections to bibliographic elements remain meaningful by prompting poetic complexity and depth from apparent nonsense. Furthermore, focusing on improvisation illustrates the many modes of creativity that cycle around such works in both creators and viewers as they play with type.

In their respective books, beaulieu and Mancini engage with typographic forms in two distinct ways. beaulieu composes, with recognizable letters, poems that riff off typographic and bibliographic affordances to reconstruct perceptions of language, ranging from cyclic confines to transformative ruptures. beaulieu's poems prompt reorientations and reconceptualizations of extant linguistic artifacts, injecting novelty and fictivity into the typographies of daily life. On the other hand, Mancini actively decomposes and reconstructs letters themselves, dissecting their affordances to compose alternative ones while maintaining vestiges of their former selves. His poems prompt a strong sense of fictive motion as we scan for points of recognition, with the fictive change glimmering out only once we notice the facets of butchered letters within. Mancini's titles also add another variable to interpretative processes, as they present the only point of authorial assertion in response to the unexpected artifact. His titles act as an expression of his own readerly improvisation in response to the poem, which then guides subsequent viewers interactions. The titles present surprising congruencies with the postlinguistic poems, confirming the meaningfulness of the oft-ignored lettristic forms that his poetry makes salient through their annihilation. These poems act as speculative fictions for language; they revel in undercutting any sense of stability that written language affords by showcasing novel interactions with type that contrast the static containers of the conduit metaphor with the dynamicity of improvisational, embodied creativity.

Both authors engage in improvisational methods informed by the affordances of writing, either at the level of the letter or its composite parts, and within the confines of the page. Readers respond through mental simulation, improvising through postlinguistic nonsense and bibliographic backgrounds back to meaning. The material creativity on both sides shifts understandings of meaning away from linguistic determinacy towards sensations, patterns, and fictive projections grounded in organismic experiences. The multimodal, embodied approach presented here interweaves perception and conception to introduce a methodology

that helps to unpack the material and conceptual affordances and proliferations these poems and their poets revel in. This approach addresses how the static forms of visual poems prompt contemplation, critical depth, and multiplications of meaning through improvisational cognitive processes. It links this to the transgressive and transformative poetic understandings of language they prompt in the reader. The inculcation of the reader's creative responses to poems that reconfigure and transfigure language also makes them into what Martin Puchner (2006) calls "art manifestoes," which actively engage with performativity and representation. In postlinguistic visual poems, vestiges of the conduit remain, but with kinks, holes, and eddies disrupting and energizing expressivity through a tactile engagement with, and reanimation of, the materials and modes of communication. The poetic and dynamic richness of these poems would remain largely untapped without this embodied perspective on visual and linguistic creativity and meaning, helping us feel our way out of the postlinguistic, lettristic dark.

ACKNOWLEDGEMENTS

My gratitude to derek beaulieu and Donato Mancini for their kind permission to reprint their poems. My thanks to Barbara Dancygier, Eve Sweetser, Kevin McNeilly, and Sherrill Grace, as well as participants at several conferences and the generous reviewers of this article, for their insightful comments on parts of this paper at various points in its development. All errors and omissions are my own. This work was supported by a doctoral scholarship from the Social Science and Humanities Research Council of Canada.

Most importantly, the love, patience, and support of Brianna, Madeleine, and Zoë, made it all possible.

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ABOUT THE AUTHOR

Mike Borkent is a doctoral candidate at the University of British Columbia, Vancouver. He studies cognitive approaches to visual literatures and poetry, focusing on North American comics, graphic novels, and visual poetry. He recently co-edited a volume on *Language and the Creative Mind* (CSLI 2013) with Barbara Dancygier and Jennifer Hinnell, and has authored another paper on visual poetry, "Illusions of Simplicity" (2010), which was reprinted in 2012. He was also the head developer and co-author of *CanLit Guides* (www.canlitguides.ca) for the journal *Canadian Literature* (2011-14).

Book Review:

Design for information, an introduction to the histories, theories, and best practices behind effective information visualizations.

by

Isabel Meirelles

Beverly, MA: Rockport Publishers, 2013.

Jorge Frascara

Design for information is a thorough representation of both the field of information visualization and the research interests of the author, whose focus is on "the theoretical and experimental examination of the fundamentals underlying how information is structured, represented and communicated in different media."

Beginning with the "big picture," the book includes an amazing collection of examples, the most thorough I have seen to date in a volume. The author organizes the content according to several categories represented by the titles of the chapters: 1. Hierarchical structures: trees; 2. Relational structures: networks; 3. Temporal structures: timelines and flows; 4. Spatial structures: maps; 5. Spatio-temporal structures; and 6) Textual structures. An appendix, notes, a bibliography, a contributors list, and an index complete the content of the book.

Design for information is an extensive taxonomy of data visualization types and is "a must" for anybody interested in the work done in the area. Each one of the hundreds of examples is explained and discussed, forming a kind of encyclopedia on the subject. It seems that nothing escaped the exemplary collection that Meirelles assembled. The discussions and explanations normally focus on what information is represented and how it is represented.

It is interesting to see, as well, how many different professional fields today use diagrams to organize and represent information: basic science, applied science, education, engineering, medicine, and technologies, etc. The value of the book is centered on the inclusion of examples of how many different problems are now being addressed through data visualizations, how many historical efforts preceded whatsoever is

done today, and how the advent of the computers have allowed the field to explode by handling large data sets as well as dynamic representations.

At the end of the examination of the 224-page volume I became curious as to how these diagrams might have performed with the users they were intended for in terms of ease of comprehension; what conclusions I could arrive at from an evaluation of the examples from a perceptual and cognitive human factors perspective; or how a complementary book could contribute to the development of best practices. I would not expect that one volume could be so extensive as this one and also cover the field critically. However, I have to wonder how the super-complex visualizations permitted by computer programs today would perform regarding comprehension, memorization, and use of the information presented. The discussion on perception and cognition is very brief, and it might leave some readers wondering about the assertions made: they are proposed as principles without them being discussed. This topic, as well as Gestalt theory, are not considered during the description of examples. The size of some reproductions is too small to assess their quality as data visualizations. They appear as examples of problems addressed but not as information in themselves. To compensate for this, the book includes valuable URLs for people interested in seeing in better detail many of the diagrams shown.

While the above issues could be perceived as weaknesses, the strength of the book is its truly amazing array of examples and the rare historical diagrams it offers. It also displays an uncommon erudition and includes an extensive and useful bibliography. I do not know how long Meirelles took to complete the manuscript, but it feels like a lifetime project. These assets, coupled by excellent production, make this an indispensable publication for anyone interested in information visualization.

Book Review:

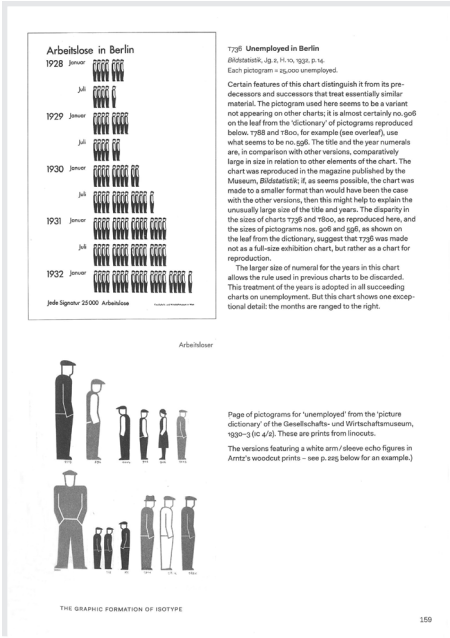
Isotype: Design and contexts 1925–1971

by

Burke, Christoher; Kindel, Eric; Walker, Sue (Eds.)

Hyphen Press, London, 2013

Per Molleup



Page 158
Males with flat cap and hands in pocket stereotype unemployed persons. Striking workers have crossed arms.

Isotype, why not?

The term Isotype, an acronym for International System Of TYpographic Picture Education, is a technique of data visualization introduced by sociologist, economist, and philosopher Otto Neurath. Originally called "The Vienna School of Pictorial Statistics" and developed and practiced at the Gesellschafts- und Wirtschaftsmuseum in Wien (Social and Economic Museum of Vienna), 1925-34, Isotype's purpose was to communicate societal information to visitors. In 1935, Neurath's technique was renamed, and Isotype began its own life and was used for other purposes in other places.

Isotype builds on the idea expressed in Neurath's often-repeated adage, "To remember simplified pictures is better than to forget accurate numbers" (p. 85). Therefore, Isotype is best known for Picture tables—graphic displays with rows of repeated pictograms each standing for a number of real world units. The picture tables embody the proposition that it is easier to compare quantities by comparing numbers of well-presented symbols, than to compare symbols of different size. Pictograms in the Isotype picture tables are scaled: in a display showing unemployment, each pictogram would stand for 1,000; 100,000; or 1 million – or another round number of unemployed persons. In picture tables, the reader must count the pictograms in different groups and multiply with the scaling factor to get the total amounts. The number of the repeated pictograms in a picture table is most often rounded off. Some Isotype picture tables feature half, quarter, or smaller fractions of pictograms. Even then, Isotype displays are typically not as precise as the numbers they represent.

Isotype: Design and contexts 1925-1971 describes Isotype in a period delimited by 1925 when the Gesellschafts-und Wirtschaftsmuseum in Wien was founded and 1971 when the Isotype Institute in London closed. The book comprises 12 chapters dealing with the genesis and further development and design of Isotype. The book includes two kinds of information; it describes Isotype design principles, and it describes the process by which Isotype was developed and disseminated. To this reviewer the former part is the most interesting, while the latter part serves as a useful historical backdrop.

TEACHING MUSEUM

In the first of two central chapters, Christopher Burke covers the ten-year lifetime of The Gesellschafts-und Wirtschaftsmuseum in Wien including the formative years of Isotype. The idea behind Isotype predated the museum. Otto Neurath, sociologist, economist, and philosopher, had already applied charts with pictorial descriptions of quantities for the Museum für Siedlung und Städtebau, Museum for Settlement and Town Planning. Eager to educate by means of these didactic tools, Otto Neurath suggested a new museum to expand the ordinary population's understanding of national and world relations. The social democrat regime in Vienna understood the importance of education and provided the necessary financial support.

Otto Neurath invented Isotype, but more than that, he promoted it. Philosophically and organisationally trained in addition to being well connected academically and politically he spread the word and established the connections that were vital to the incubation of a new idea like Isotype. Neurath partnered his strong interest in education of ordinary people with his equally strong social commitment resulting in his belief that progress depends on knowledge, and knowledge should be delivered in ways that are both attractive and memorable – essential qualities of Isotype.

The Gesellschafts und Wirtshaftsmuseum in Wien was not a museum in the traditional sense of that word; and therefore consistent with Neurath's view that "The modern museum should be a teaching museum, a means of education, a schoolbook on a grand scale…" (p. 30). The Gesellschafts and Wirtshaftsmuseum in Wien consisted primarily of graphic charts explaining societal matters, first and foremost quantities. The museum introduced a number of advanced ideas to meet its audience. To accommodate prospective visitors the museum was open evenings and Sunday mornings. Also, the museum branched out at several places where visitors would be. At a certain time, the museum would exhibit at several different locations in Vienna including the town hall. A central corner shop museum open in the lunch hours had as many as two thousand visitors a day. At the corner shop special interactive knowledge machines were placed where visitors could test their knowledge – anticipating a distant, digital future. Exhibition material was reused and exchanged between permanent

and time limited exhibitions in several places. Along with its own exhibitions, the museum took part in fairs and exhibitions in Austria and abroad.

The museum also published books, pamphlets, and journals to reach its audience in time and space. *Gesellschaft und Wirtschaft*, Society and Economy, was a collection of 100 Isotype charts. *Fernunterricht*, distant teaching/learning, later renamed *Bildstatistik*, Pictorial Statistics, prefigured modern distance learning.

Three persons led the development of Isotype: Otto Neurath, a sociologist, economist, and philosopher; Marie Reidemeister, a German academic; Georg Arntz, a German graphic designer.

Austrian Otto Neurath's past career included his initiative to, and directorship of, the German museum of war economy in Leipzig during WWI. After the war, his presidency of the Central Office of Economics, in the Bavarian Soviet Republic, was followed by a conviction of assisting high treason and an eighteen-month, later suspended, prison sentence. In 1920, Neurath was back in Vienna to become the director of the Forschungsinstitut für Gemeindewirtschaft, Research Institute for Co-operative Economy. In this capacity Neurath initiated a Museum for Settlement and Town Planning, which within a year – also on Neuraths initiative – was replaced by The Gesellschafts-und Wirtschaftsmuseum in Wien.

Marie Reidemeister (after 1940 Marie Neurath) met Otto Neurath before the start of the Gesellschafts- und Wirtschafts Museum in Wien, became his right hand, and continued working with Isotype after Otto Neurath's death in 1945. Most importantly, Marie Reidemeister played and developed the role of 'transformer'. Otto Neurath and Marie Reidemeister considered the 'transformation' of a message into a principle for a graphic chart the crucial part of the work with Isotype. Transformation was the link between science and graphic design. According to Marie Reidemeister: "We think out which is the point that has to be brought home, and then we try to do so in such a way that everybody will grasp it. We avoid distracting the attention from the more important issues." (p. 15). Also according to Marie Reidemeister, other designers impressed by Isotype would emulate the form but hardly master the transformation (p. 14). Today, the term 'transforming' is not used, but the substance is a natural part of the work of information designers engaged in data visualisation in news media and elsewhere.

Georg Arntz was a German artist working with woodcuts in precise graphic shapes, which caught the attention of Otto Neurath. Georg Arntz began working for the museum in 1928 and in 1929 moved to Vienna where he developed the schematic graphic form that became a signature quality of Isotype. In the process he also changed the technical production from paper cuts to printing from linocuts.

Three conditions for launching Isotype were present. First, a strong-minded initiator with a firm social and educational commitment who was well connected politically; second, highly qualified principal collaborators; and third, a friendly political market.

Partly inspired by the political winds and the following possible need for a foothold outside Austria, Otto Neurath established in 1932 the affiliate Mundaneum to take care of international relations. In 1932 and 1933, Mundaneum established branches in Amsterdam and London respectively. In 1934, the International Foundation for the Promotion of the Vienna Method of Visual Education was established in The Hague. Later in 1934, when the political situation in Austria and Vienna as envisioned by Neurath became dangerous, he, his wife Marie Reidemeister, Georg Arntz, and two other collaborators moved to the Netherlands. The Gesellshafts- und Wirtschaftsmuseum was closed. Part of its material was already transferred to Mundaneum. The rest was seized by the new regime, not the first time a design initiative has been subject to political change. In 1940 the Neuraths moved on to England.

THE NETHERLANDS

Two chapters of the book deal with the continuous work in the Netherlands and England. In Vienna, Isotype had been a means to inform the visitors of the Gesellschafts- und Wirtschaftsmuseum. In the Netherlands the Neurath team had to earn their way from projects. Otto Neurath wrote two books in Basic English: *International Picture Language* and *Basic by Isotype*. Other jobs included production of a children's theatre puppet show and an art exhibition, *Rondon Rembrant*. Also, commissions resulted from Otto Neurath's frequent travels to the USA.

ENGLAND

When Germany occupied the Netherlands the Neuraths moved on to England, where Otto Neurath had been promised a teaching position at Oxford. The Isotype Institute was then established in 1942. The Isotype work in England followed two lines. The Neuraths wrote and designed a number of books for Adprint, a book packager who also published, and they worked on informative films together with British film producer John Rotha. The books dealt with the war effort and social policy. Apart from a couple of booklets this work included a three book series: *America and Britain*, *The Soviets and ourselves*, and *New Democracy*. Two chapters in *Isotype: Design and contexts 1925-1971* deal with film work and children's books respectively.

FILM

Documentary filmmaker John Rotha approached the Neuraths soon after their arrival in England to initiate a collaboration concerning films for the Ministry of Information. The first film, *A few ounces a day* about saving waste to be used in the war effort, was based exclusively on animated Isotype graphics. The Neuraths acted as de facto directors and Maria Neurath made a complete storyboard as well as the graphics to be animated. Later followed several films, where Isotype animations were combined with live action. A series of films that had significant results included, *Worker and*

warfront, which was shown for workers in factory canteens, *World of Plenty* and *Land of promise* which dealt with food and with planning respectively.

In 1945 Rotha established a special company, Unifilm, with himself and Otto Neurath as directors. After Otto Neurath's death Marie Neurath would continue the cooperation with John Rotha until 1948, when Unifilm closed down. In 1954 Marie Neurath contributed to a TV series, *The World is ours*, and in 1965 to a film *The physics and chemistry of water*.

The film work was not without problems. Some critics found that serious matters should not be treated through the genre of animation. The Neuraths complained when they did not have full control of the work, and Paul Rotha did not always find the necessary support for Isotype work from the Ministry. Professional designers recognise these kinds of problems. Otto Neurath also had some didactic reservations. Isotype on paper lets the viewer see and compare several displays concurrently in space, while film – working in time – doesn't provide that possibility. Also paper media, in contrast to film, gives viewers as much time as they want. Today video technology has solved this problem.

CHILDREN'S BOOKS

In her chapter about children's books Sue Walker rightly states that "The children's books produced by the Isotype Institute provide an excellent insight into Marie Neurath's work as a transformer and show that she had a particular skill in making charts and illustrations that were accessible to children of all ages." (p. 391). This chapter reaches beyond children's books: The account of Marie Neurath's approach is relevant to all designers concerned with data visualisation.

The children's book production took place from the 1940s into the 1970s. Otto Neurath took the initiative, but after his death Marie Neurath edited, wrote, and designed a large number of children's educational books, some of which were schoolbooks. Children's book series included *If you could see inside*, *I'll show you how it happens*, *Visual history of mankind*, *Visual science*, *Wonders of the Modern world*, and *Wonder world of nature*. The Isotype institute delivered both the text and design for these books. Illustrations would include pictograms and all kinds of explanatory drawings. In another series, *They lived like this*, the majority of the illustrations were drawings of contemporary artefacts. This series was co-written by external artists.

Marie Neurath's thoughts about the work with children's books are interesting to everyone working with data visualisation:

> I had to ask myself: what are the essential things we want to show, how can we use comparison, direct the attention, through the arrangement and use of colour, to bring out the most important things at the first glance, and additional features on closer scrutiny. Details had to be meaningful, everything in the picture had to be useful for information. (p.395)

From a note addressed to the readers of the second book in the Visual history series:

> Everything which would not help you understand the meaning, or which would confuse you, is left out. Colours are used only to help make the meaning clearer, never simply as decoration. This means that every line and every colour in these pictures has something to tell you. (p. 403)

USA

Three factors obstructed Isotype's introduction into the USA. The timing was not good. It was the middle of the depression, there were several imitators (just competitors?) around, and there was Rudolf Modley, a former part-time employee in the administration of the Gesellschafts- und Wirtschaftsmuseum in Wien. Rudolf Modley would cooperate and compete with the Isotype team in Den Hague and Oxford, and challenge Otto Neurath's views.

A group of influential supporters worked together to get Otto Neurath and Isotype to the USA. When in 1930 there was an opportunity to use Isotype at the Museum of Science and Industry in Chicago, Otto Neurath recommended the employment of Rudolf Modley. Here and later Modley acted more independently than envisaged by Otto Neurath.

In 1934 the supporters founded the Organizing Committee for the Institute for Visual Education "to establish in the United States an organization which can develop and promote the graphic methods of presenting social and economic facts, which have been characterised by the Vienna Method as exemplified in the work of the Gesellschafts- und Wirtschaftsmuseum in Wien under the direction of Dr. Otto Neurath" (p. 307). When the organisation did not follow Modley's advice, he created his own company, Pictorial Statistics Inc. Otto Neurath and Rudolf Modley held differing views. Neurath wanted standardised pictograms designed centrally while Modely had a more relaxed view. Neurath explained:

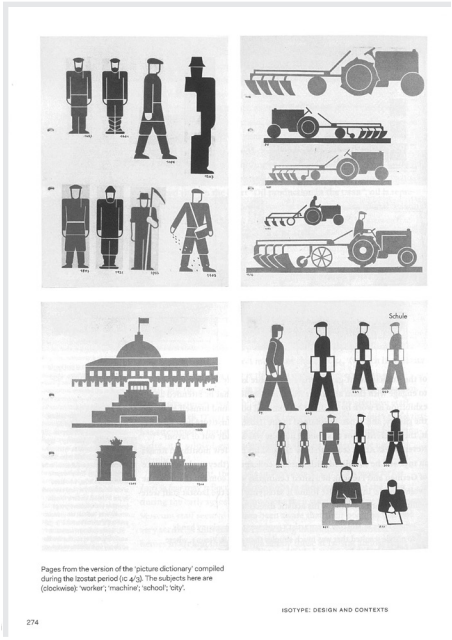
> That is to say, for our picture language one general list of a limited number of signs is needed for international use, and this has to be worked out by or under the control of one chief organization (This organization is now the ISOTYPE work-room at the Hague). (p. 332).

Also, Modley saw the pictograms as elements that could have their own life while Neurath saw pictograms as parts of visual arguments enabled by transformation. Modley was not interested in transformation. In line with this view he published symbols sheets with pictograms to be used by everyone and a book entitled, *1000 Pictorial Symbols* (1942).

Otto Neurath travelled to the USA several times and secured important commissions, primarily in the health sector. Isotype also delivered illustrations to *Compton's pictored encyclopedia* (1939) and Otto Neurath wrote *Modern man in the making* (1939) for Knopff publishers. After Neurath's death Marie Neurath wrote an essay on Isotype for Henry Dryfuss's *Symbol Source Book* (1972).

RUSSIA

The Isotype team's efforts in Russia took place from 1931-1934. Russia did not want to commission Isotype work from Vienna. Instead, they wanted Isotype staff to help establish a Soviet institute. A special organisation named Izostat was established with Otto Neurath as one of two directors, and several Isotype staff would join them for shorter or longer periods. The total staff at times would be as high as 75. A number of problems hindered cooperation. The work primarily dealt with visualising the established success of the first five-year plan 1928-1932 and the predicted success of second five-year plan 1933-1937. While The Vienna Method as practiced in Vienna was based on empirical facts, the Russians wanted forecasts to play an essential role. The estimates were often exaggerated. Another problem was that the Russians wanted naturalistic pictograms aligned with wanted Soviet realism. Also, the Russians wanted more, sometimes propagandistic, illustration. The cooperation resulted in some publications with more or less Viennese influence. Georg Arntz made a series of charts for Izvestia, charts for exhibitions, and a number of publications more or less influenced by the Isotype team. One Isotype idea was used with a new meaning. In the Vienna Method black was sometimes used to illustrate worse, while red would stand for better. In Russian charts red would stand for Russia while black would stand for other nations.



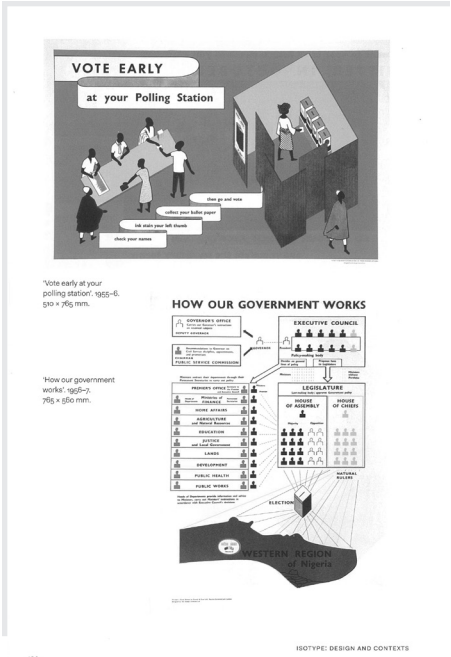
Page 174
Isotype work for Izostat in Moscow characterised by Russian realism.
(original in color)

In 1934 the Russians wrote to Otto Neurath that the contract did not comply with Russian law and the amount due at the end of the contract would not be paid. The latter incident was a major blow to the Isotype organisation, which in Den Hague depended on paid work. Izostat continued without Isotype help until 1940.

AFRICA

Some Isotype work in Africa took place from 1952-1958. Otto Neurath reportedly said that Isotype was not for the Viennese, but for the Africans (p. 449). In 1943 he worked on a proposal for an exhibition for the British Colonial Office entitled, *Human life in Africa*. This project did not materialize.

In 1953 a partnership between Buffalo Books, a subsidiary of Adprint, the Isotype Institute, and Purnell and Sons, a printing firm, planned and published the magazine *Forward* addressing the three British colonies Gold Coast (Ghana), Sierra Leone, and the Western Region of Nigeria soon to become independent. A trial issue and an issue number 1, dealing with culture, adventure, sports, and practical advice were published before the magazine was determined to be economically impossible in 1953.



'Vote early at your polling station', 1955–6. 510 × 765 mm.

'How our government works', 1956–7. 765 × 560 mm.

Page 480
Isotype work with limited abstraction for Western Region, Nigeria, promoted participation in an upcoming election. *(original in color)*

In 1954 Marie Neurath wrote a memorandum sketching what Isotype could do in the Western Region of Nigeria. It included a visual explanation of the aims of the government and the establishment of a local workshop for Isotype run by trained Nigerians. Marie Neurath visited Africa three times and a series of booklets and poster-leaflets were produced, while the workshop remained a plan.

For the Western Region a series of 16-page White Paper Booklets were published including *Education for all in the Western region*, *Better farming for better living in the Western Region*, *Health for all in the Western Region*, and *Paying for Progress in the Western Region*. Also a series of poster-leaflets dealing with health issues was produced. As indicated by the name, the poster-leaflets worked both as wall charts and as folded leaflets to take away. A following visit to the Western Region resulted in commissions for a new series of booklets.

Compared with the Western Region in Nigeria the Gold Coast and Sierra Leone had little work for Isotype. In 1956 Isotype made one leaflet for The Gold Coast, *The Volta River Project: what it means to you*, and in 1957 one for Sierra Leone *Voting, general election*.

In the late fifties the Isotype work in Africa came to an end. The chapter author, Eric Kindel, offers a number of probable explanations, one being the distance, another being the failure to establish a local workshop with trained local people. To the Isotype Institute the African experience meant realising the need for locally adapted symbols for man, woman, house, and more. The pictograms should 'speak'. In the same vein, charts were given familiar backgrounds. According to Marie Neurath: "[A]dherence to the method cannot go as far as imposing an alien background on those unable to share one's experience of it." (p. 495). This did not, according to Marie Neurath "imply that the system had to be radically changed" (p.495).

DESIGN

In the second central chapter of the book, Robin Kinross presents the design of Isotype. This chapter was originally a part of Kinross's MPhil thesis from 1979. (Robin Kinross is the owner of Hyphen Press, the publisher of this book as well as Otto Neurath's 'visual biography': *From hieroglyphics to Isotype* (2010) and a string of well presented books on typography.) The provenance of the chapter may explain the order in which it deals with the subject. The description begins with the formats of the wall charts, and moves through

colour, male and female, qualifying symbols, and guide pictures, down to pictograms and configuration. In the latter part Kinross codifies six types of displays dealt with by Isotype. This would have been a natural start of the chapter to be followed by pictograms. Apart from this peculiar arrangement the chapter gives a robust description of the elements used in Isotype. Kinross calls Isotype "a coherent approach to ordering material in graphic form" (p.107). It covers what we today call 'data visualisation'. In contrast to the remaining part of the book, Kinross offers a few critical remarks on Isotype.

Considering Neurath's interest in education it is remarkable that there exists no manual, no single, document explaining the Isotype design principles thoroughly. One reason could be that Isotype remained a work in progress. Another reason could be that Neurath did not want everyone to design visual displays, but rather to commission the displays from the initiators. So-called notes, single sheets each describing a design subject, were descriptive rather than prescriptive. They described current practice more than recommending what should be done. Also, Neurath's publication, *International Picture Language*, 1936, written in Basic English doesn't serve as a manual either.

Kinross's description of Isotype design gives a clear impression of Isotype being a work in progress. Pictograms, qualification, grouping of pictograms, use of colour, use of typography, and configuration would change considerably between 1925 and 1934, especially after Georg Arntz joined the team. However, this development did not always follow a straight line. Different principles were sometimes used concurrently; old design features were sometimes used after new design features were introduced. The development involved standardization, modularization, and simplification. Pictures would be reused and be combined; the use of colours would be restricted.

Kinross refers to the common misunderstanding that "quantified rows and columns" "might be typical of the work as a whole" (p. 142). Well, these picture tables and their pictograms are what most of us think about first when we think about Isotype. The picture tables and their pictograms are featured on the covers of publications and wherever Isotype is discussed. Kinross shows the width of Isotype by the following classification (p. 139).

Charts showing quantified material:

1. rows and columns [picture tables],
2. division of a whole (usually a checker-board),
3. geographically ordered pictograms and more diagrammatic charts,
4. quantities related to area (usually showing densities),
5. flows.

Charts showing non-quantified material:

Neurath broke down the picture table category into six sub-categories (p. 140):

1.1 comparison of total quantities,
1.2 where sizes of constituent parts are interesting, as well as total quantities,
1.3 where relative sizes of constituent parts are most important,
1.4 to make a shift particularly clear; alignment left and right to form an axis,
1.5 where the sizes of parts and of wholes are equally important; one compares both horizontally and vertically,
1.6 to allow comparison of parts and wholes, and to make a shift clear; especially important in showing changes over time.

A schematic drawing and an Isotype picture table illustrate each of these sub-categories.

While the fact that a large part of the text of this chapter is devoted to picture tables and pictograms may support the idea that Isotype first and foremost is picture tables, the book's numerous illustrations establish some balance. Isotype is both picture tables and a general approach to data visualisation.

In a chapter about pictograms, Christopher Burke confirms that a direct line from the Isotype pictograms to the pictograms used in transport and communication today hardly exists. However, qualities such as standardization, modularity, and schematization are parts of the Isotype heritage. Isotype pictograms worked in lines in picture tables to compare something, while modern pictograms in transport and communication simply point to the existence or condition of something. Otto Neurath, however, suggested that the Isotype pictograms could possibly also be used for public information signs. This application was not realised.

WHY NOT?

Isotype: Design and contexts 1925–1971 is a comprehensive introduction to the Isotype idea. The book's 12 chapters written by nine authors are well planned with a minimum of overlaps. While the main text goes into considerable historical detail, the illustrations present the elements and charts by which Isotype should be known and appreciated. The numerous illustrations – more than 400 – and their elaborate captions turn the book into a portable archive, which for everybody unable to access the Isotype collection at University of Reading will remain the most important Isotype resource.

Implicitly the book relays a well-known phenomenon: how a design idea born to solve one problem if successful becomes a

solution that looks for other problems. From informing the Viennese citizens the problem changed into finding potential outlets for the newfound method.

In the beginning of *Isotype: Design and contexts 1925–1971* Christopher Burke states, "The best way to bring these [the qualities of Isotype] to the fore is to examine it as a historical phenomenon in all the complexities of its contexts." (p. 14). This is questionable. To compare is the basic function of Isotype. Isotype should itself be compared with competing data visualizing formats. How can we evaluate the virtues of airships without comparing airships with other airborne vessels?

We still need a balanced discussion of the qualities of Isotype. What exactly is the Isotype approach? How does it survive today? How does Isotype compare with the display formats that news media and others prefer today? What are the pros and the cons of Isotype compared with other more frequently used data visualising formats such as bar charts, bubble charts, and line charts? Understandability, accuracy, attraction, and memorability are factors that should be discussed. The discussion should also include the intended target groups of Isotype and the contemporary audiences of news media and professional literature. Is Isotype only for uneducated people?

One probable finding is that most contemporary audiences prefer exact information to the visual explanation offered by Isotype picture tables. Today bar charts, pie charts, and bubble charts, which in principle present *visual* messages, are as a rule supplied with exact figures. Such displays are hybrids. They are half visual display, half table. The visual part lets the reader get a fast idea, while the figures deliver accuracy. In a short period Isotype's picture tables were also supplied with exact figures. In later displays the figures were abandoned. The big, undisputable advantage of isotype displays is that they are attention grabbing and attractive to look at. The visual attraction may be accompanied by good memorability.

P S

Design and contexts 1925-1971 is well crafted with a pleasing design. However, there are two minor flaws. First, the key to source abbreviations is located on page 18, while readers expect to find it in the beginning of the book where it would be easy to retrieve for later reference. Second, tiny, alphanumeric caption designations of up to four characters are written with lowercase numerals (6 and 8 with ascenders and 3, 4, 5, 7, and 9 with descenders), which are difficult to read, especially when presented in the very small type used for marginalia.

Per Mollerup
14 August 2014

THE MOST IMPORTANT DESIGN BOOKS MOST DESIGNERS HAVE NEVER READ:*

The Case for Mental Imagery

by

Stephen M. Kosslyn, William L. Thompson, and Giorgio Ganis

Mike Zender

date: 2035 CE
location: a design office

The designer looked at the screen and watched the child's memory of being sick. "I'm sorry to ask you this, but think of diarrhea again please," she said. The toilet shimmered into view briefly followed by transparent wavy lines. The designer noted the lines, then replayed the other children's memory and noted that 67% of them included shimmering, wavy lines to represent smell. "Thank you, that's all I needed. You've really helped me design this icon," she said.

Paul Rand once said that communication design is about "saying the commonplace in an uncommonplace way." (Rand, 1970, p. 36) This suggests that effective communication is essentially enhancing the familiar. For visual communication design, this means creating unique images that will connect in predictable ways with the images people already hold in their minds. From this perspective, the whole user-centered design movement is a cultivation of means for designers knowing, not just assuming, the mental images people have. Stephen Kosslyn, William L. Thompson, and Giorgio Ganis' book *The Case for Mental Imagery* (Kosslyn, Thompson, & Ganis, 2006, p. 4) gives designers an accurate glimpse into how mental images work.

MENTAL IMAGES

The plausibility of the fictional design office above hinges on the answer to a debate that has raged for at least decades, perhaps centuries: do we see mental images or not? According to Kosslyn, Thompson , and Ganis, "A mental image occurs when a representation of the type created during the initial stages of perception is present but the stimulus is not actually being perceived." Mental imagery is seeing what is not there, not an illusion or a mirage, but seeing in our mind something familiar and then perhaps using that mental image to think with or solve a problem. We might experience this by answering this question: how many windows face the street in your house or apartment? Given this task most people gaze blankly for a second

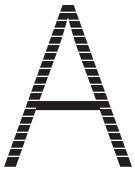
or two as they push into memory an image of their house and then briefly count the windows in the image. Kosslyn et. al. cite similar questions such as "Do you know which is darker green, a frozen pea or a pine tree? Or the hand in which the Statue of Liberty holds the torch" as examples where people use mental imagery.

Belief that this phenomena exists are not new. The authors briefly note that thinkers from the classic Greeks to Einstein claimed to use mental images "in memory, problem solving, creativity, emotion, and language comprehension." However, introspective experiences are notoriously difficult to study, easy to refute, and thus ripe territory for endless debate. Kosslyn, Thompson, and Ganis use Chapters 2 and 3 to detail the debate, Chapter 4 to marshal empirical findings from a broad range of cognitive psychologists and neuroscientists in order to settle the debate, and Chapter 5 to articulate a well-founded theory of mental imagery.

The theory articulated in the book is based on the process of visual perception which it describes. The eye is just the start of a process that occupies much of the brain. In fact, approximately 50% of the cerebral cortex is devoted to visual processing. The brain is not like a general-purpose computer with generic processing capacity to which are downloaded different problems for analysis. Rather, the brain is like a special purpose device with different neurons in different regions hard-wired to accomplish specific tasks. Vision is one of the brain's largest tasks. In visual perception a huge volume of sensations are processed and reduced to simpler more organized forms. It's as if individual camera pixels are processed for simple features then structured into units that correspond to distinct objects and key properties that define and distinguish those objects from each other. Kosslyn and his colleagues propose that we can reverse this process and push the abstracted memory of a visual object backward onto the brain's early visual processing areas and there mentally re-construct a representation of something. Representation is a key idea here. The authors point out that stored depictive representations are not like photographic pictures. They are simplified forms that can be re-presented and then examined and to which detail can be added. It may help communication designers to think of these abstracted representations as "brain icons" because they, like drawn icons, are simplified and focus on key features of an object or idea rather than inessential details. We can use these mental images to reason about problems, like whether a jar could squeeze into a crowded pantry shelf, or to communicate with people by creating images that connect with their visual imagery. It is important to note that understood this way, there is a deep and complex relationship between seeing and thinking that deserves attention.

COMPETING THEORIES

Kosslyn et. al. identify the core of the debate as two competing conceptions of the format we use to store internal visual representations: depictive



Depictive format above

FIGURE 1

FIGURE 2

Propositional format below

"two diagonal lines that meet at the top, joined halfway down by a short horizontal segment."

(Kosslyn et al., 2006, p. 12)

or propositional. The depictive approach suggests that our brain encodes images in a visual format using points, similar to the way a computer screen uses pixels. The blocks forming the triangle in Figure 1 illustrate a depictive format. The propositional approach suggests that we format images using abstract concepts like words in language or computer software. The words "two diagonal lines that meet at the top, joined halfway down by a short horizontal segment." in Figure 2 illustrate a propositional format for the same image.

The format used may seem like an academic debate, but it matters because the format of representation makes possible, or at least preferences, different kinds of thinking and from this the creation of different knowledge.

To settle the debate the authors call upon findings that add significant detail to the outline of the perceptual process noted above. Very early in this process the image from our retina is topographically mapped point-for-point on our brain. Objects close to each other on our retina are also close to each other on the cortical area called V1. There are, in fact, several topographically organized layers in V1 with each layer providing different kinds of processing. Cutting down through layers are columns that distinguish different line orientation, curve, value, and hue. These topographic layers are part of what Kosslyn labels the "visual buffer." The "visual buffer" then "reports" the results to other areas of the brain where patterns and shapes are assembled, where objects are formed and subsequently identified. Kosslyn asserts that through these successive stages a "population code" is assigned containing in abstracted form the key visual features that define an object. Kosslyn posits a "hybrid representation" that combines information for each point about its role in the depiction of the object, as well as additional abstracted information. "In spite of their coding nondepictive information, these hybrid representations cannot be reduced to propositional representations. Crucially, they use space (literally, on the cortex) to represent space in the world. The fact that each point codes additional information does not obviate its role in depicting the shape."

The highlight of Kosslyn's argument is that these encoded representations can be recalled and when they are, an image is reconstructed from memory using the same topographic neural space in the "visual buffer" that was used to "see" the initial image from the eye. In Kosslyn's words, the "stored shape representation is primed so strongly that activation is propagated backwards, including a representation of a part or characteristic in the visual buffer (which corresponds to the depictive image itself)." Kosslyn theorizes that we literally re-construct the object from memory and create a representation of it. These are mental images.

VALIDATION

When Kosslyn and his colleagues wrote this book some years ago the viability of their theory was still open to debate. But much has happen since then to support its basic premises.

In 1988 Tootell et. al. provided a foundation for how we see when they showed a topographically represented visual image mapped on the surface of a primate brain. Over the years various scientists have developed techniques that enable them to dye a primate brain and see there on the cortex - in real time - the images from the eye. A 2012 NIH presentation by Dr. Eyal Seidemann is one example of video showing this. ("Decision Related Activity and Top-down Attentional Modulations in Primate VI" http://videocast.nih.gov/summary.asp?Live=11769&bhcp=1) More recently researchers used fMRI to produce an image of a person's recalled memory (mental image) of a simple object. In 2014 Dr's. Cowen, Chun and Kuhl presented findings that through observing brain activity they were able to reconstruct recognizable individual faces from people's mental images of faces they were seeing ("Neural portraits of perception: Reconstructing face images from evoked brain activity" in *Neuroimage).* The title of the March 28, 2014 Fox news article reporting this paper was *"We know what you're thinking: Scientists find a way to read minds."* by Maxim Lott. While the face reconstruction study may be as much about the inventiveness of the computer processes employed as it is about the biological ones, its findings dramatically support the foundation of Kosslyn's hypothesis: mental images are seen reconstructed in the visual buffer. These studies can "see" them.

SO WHAT?

The Case for Mental Imagery may sound interesting to some readers, but to others the question "So what?" may have been lingering for some time now.

So what? How is the information in this book relevant to the designer? One answer is "A theoretical foundation for communication design." Communication design has entertained competing theories to guide practice. Some, such as semiotics, are based in linguistics. Theories of visual perception such as the one articulated by Kosslyn, Thompson, and Ganis may help provide more appropriate visual ground for a theory of visual communication. Knowing how people process, store, and use images is at the heart of visual communication. It's true that communication designers create objects that use both textual and visual forms to communicate and much has been written recently about the role of designer as author and the need for more writing in design education. Without dismissing the positive role designers can play in crafting the written content of the communication they create (designer as author), or diminishing the role writing can play for organizing and expressing thought in design classes (writing in design education), Kosslyn's theory suggests that there is a good reason that college "communication" programs focus on writing while "visual communication" programs focus on image making. Visual images are the essence of visual communication. Communication designers employ forms of communication that largely bypass language. Kosslyn reminds us that people think with images. One benefit of

Kosslyn's theory as it applies to design is that it is founded on hard-wired neurobiological perceptual processes common to all people, suggesting that design principles founded on this approach may be universal, applying to people of every age, language, literacy level, and culture. With limited research resources to invest, design might do well to focus on universal visual processes that can apply to nearly everyone before building upon theories focused on individual differences.

In addition to providing a theoretical foundation for visual communication, "Visual thinking" is another defense of the book's relevance. Kosslyn's theory, based as it is on depictive representations, means that visual designers use a visual language that is inherently more flexible and less inhibited by arbitrary encoding structures than language. Depictive reasoning can be more ambiguous and less structured than propositional reasoning. Images are more direct, less categorical, less overtly defined, and thus better suited for creative thinking and problem solving than language-based propositional representations that seem plodding by comparison. "I see" is a common visual-based metaphor for sudden understanding and an apt metaphor for visually-empowered design thinking.

"User centered" is yet another response. Kosslyn's theory means that communication designers now and in the future can reliably identify the mental images that people have, thus gaining direct insight into how to communicate with them more accurately. Designers who know their subjects' mental images can more reliably produce images that evoke the correct meaning. Knowing people's mental images moves user-centeredness into the user's head, literally. The point of view for designers might be transformative.

"Evidence-based" is another reply. Kosslyn's theory doesn't just apply to the front end of design creation, but also to the back end of design evaluation. Using people's mental images to evaluate communication objects could give not only very accurate measurement of communication but insight to corrective action. A loop of creation and evaluation based on reliable measurement of mental image may provide communication design with some solid principles for practice.

Another Paul Rand quote suggests a final answer when he states, "…the designer must steer clear of visual clichés by some unexpected interpretation of the commonplace." "Innovation" is the final answer. Design has been said to be the process of converting existing states to preferred ones. Designers don't just create what already exists; they create something new. So how can knowing the images people already have in their heads help create something new? To a designer the question is the answer. Knowing what people think enables us to take liberties, to explore novel variations and "unexpected interpretations", to both connect and expand what is in people's minds. Apart from knowing the people's mental images designers innovate in the dark, ignorant of whether their novel approaches support or hinder communication.

Kosslyn, Thompson, and Ganis' theory means several things to communication design. It means that seeing and thinking are complementary, helping to explain the effectiveness of information visualization. It means that visual communication designers who create images are directly connecting to the one of the most significant means people have for processing information, for thinking. It means that emphasis on visual thinking is one key to why design is good at creative problem solving.

If design theories should be founded on research findings in visual perception and cognition, then they will in some measure be founded on work by Kosslyn and his colleagues. It's a book that most designers should read.

Cowen, Chun, & Kuhl. (2014). "Neural portraits of perception: Reconstructing face images from evoked brain activity." Neuroimage

Kosslyn, Stephen M., Thompson, William L., & Ganis, Giorgio. (2006). *The Case for Mental Imagery*. New York, NY: Oxford.

Rand, Paul. (1970). *Thoughts on Design* (Third ed.). New York: Wittenborn Schultz.

Advisory Board

WELCOME

Visible Language wishes to welcome new advisory Board member Keith Crutcher. Keith reflects our interest in connecting to disciplines whose research is well-advanced and whose knowledge is related to visual communication.

Keith Crutcher

Keith A. Crutcher, Ph.D., has over 30 years of experience in biomedical research and technology including prior tenured faculty appointments at the University of Utah (7 years) and the University of Cincinnati (22 years), a founding role in an early stage drug discovery company (ApoLogic, Inc.), and four years serving as a Scientific Review Officer at the Center for Scientific Review at the National Institutes for Health. In the latter role, he managed the peer review of hundreds of grant applications. His academic research program, funded by the NIH, NSF, and other agencies, included studies of brain injury and Alzheimer's disease resulting in over 100 peer-reviewed publications, two issued patents, and numerous presentations. He has also served as an ad hoc reviewer for several federal agencies and private foundations as well as serving on the editorial boards of several journals including *Experimental Neurology*, *Aging Cell*, and *Neurobiology of Aging*, where he participated in the peer review of numerous manuscript submissions. He currently does consulting work for applicants seeking research funding and provides assistance in preparing proposals and navigating the peer review system at various federal agencies.

JOURNAL INFORMATION

Visible Language is an academic journal focused on research in visual communication. We invite articles from all disciplines that concern visual communication and would be of interest to designers.

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Visible Language, an academic journal, seeks to advance research and scholarship for two types of readers: academics and professionals. The academic is motivated to consume knowledge in order to advance knowledge thorough research and teaching. The professional is motivated to consume and apply knowledge to improve practice. *Visible Language* seeks to be highly academic without being inaccessible. To the extent possible given your topic, *Visible Language* seeks articles written to be accessible to both our reader types. Anyone interested may request a copy of our editorial guidelines for authors.

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Editor, *Visible Language*
College of Design, Architecture, Art, and Planning
School of Design
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016
email: mike.zender@uc.edu

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Before there was reading there was seeing. *Visible Language* has been concerned with ideas that help define the unique role and properties of visual communication. A basic premise of the journal has been that created visual form is an autonomous system of expression that must be defined and explored on its own terms. Today more than ever people navigate the world and probe life's meaning through visual language. This journal is devoted to enhancing people's experience through the advancement of research and practice of visual communication.

If you are involved in creating or understanding visual communication in any field, we invite your participation in *Visible Language*. While our scope is broad, our disciplinary application is primarily design. Because sensory experience is foundational in design, research in design is often research in the experience of visual form: how it is made, why it is beautiful, how it functions to help people form meaning. Research from many disciplines sheds light on this experience: neuroscience, cognition, perception, psychology, education, communication, informatics, computer science, library science, linguistics. We welcome articles from these disciplines and more.

Published continuously since 1967, *Visible Language* maintains its policy of having no formal editorial affiliation with any professional organization — this requires the continuing, active cooperation of key investigators and practitioners in all of the disciplines that impinge on the journal's mission as stated above.

Website
http://visiblelanguagejournal.com

Postmaster:
send address changes to:
circulation manager name
Office of Business Affairs
College of Design, Architecture, Art, and Planning
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016

Published tri-annually in January, May and October

SUBSCRIPTION RATES

United States	Individual	Institutional
1 year	$35.00	$65.00
2 year	$65.00	$124.00
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2 year	$107.00	$166.00
3 year	$153.00	$246.00

Prepayment is required. Make checks payable to University of Cincinnati *Visible Language* in U.S. currency only, foreign banks need a U.S. correspondent bank.

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**Foreign subscriptions include additional postage ($21.00 per year).

ISSN 0022-2224
Published continuously since 1967.
Index included in last issue of volume year.

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Visible Language

the journal of visual communication research

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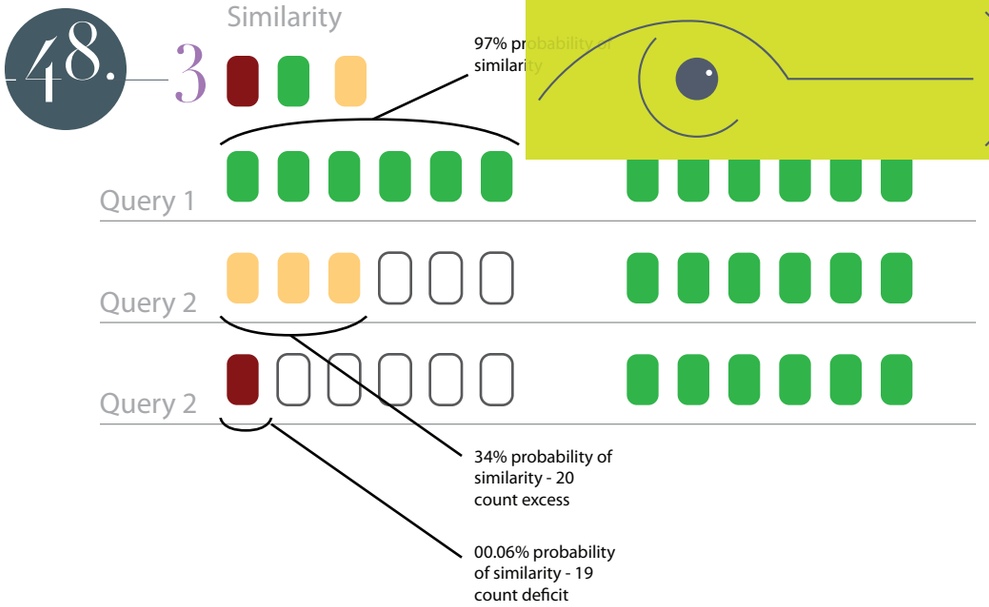
November 2014



visualization logic

50% – 100% probability of similarity = green

5% – 50% probability of similarity = yellow

less than 5% probability of similarity = red

six boxes filled in proportion to show inter-hospital similarities
six boxes need to show probability over/under 50%
six boxes can be rapidly enumerated (in about 1 second)

A Statistical Approach for Visualizing the Quality of Multi-Hospital Data

Connolly et. al.

ISSN 0022-2224

education theory

design principle

drill

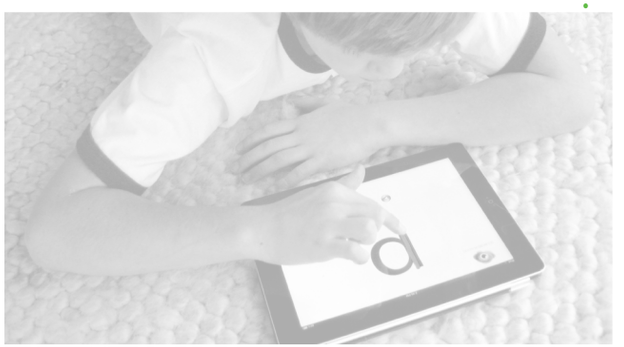
listen to sound

tactile

responsive

interaction

usability



universality

visibility

memorability

drag&drop

mnemonics

first-sound

Linking Design Principles with Educational Research Theories to Teach Sound to Symbol Reading Correspondence with Multisensory Typea

Seward et. al.

individualized

evaluation

narrative

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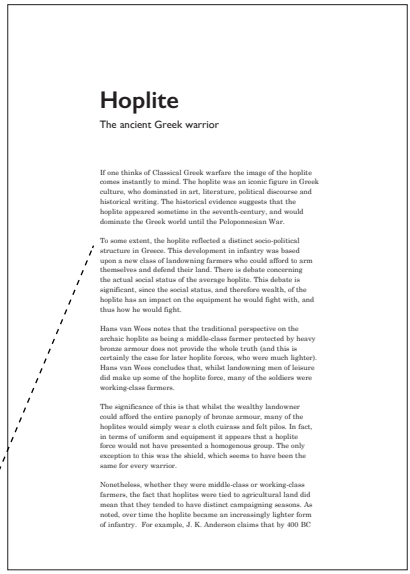
Visible Language

research



Hoplite

The ancient Greek warrior

If one thinks of Classical Greek warfare the image of the hoplite comes instantly to mind. The hoplite was an iconic figure in Greek culture, who dominated in art, literature, political discourse and historical writing. The historical evidence suggests that the hoplite appeared sometime in the seventh-century, and would dominate the Greek world until the Peloponnesian War.

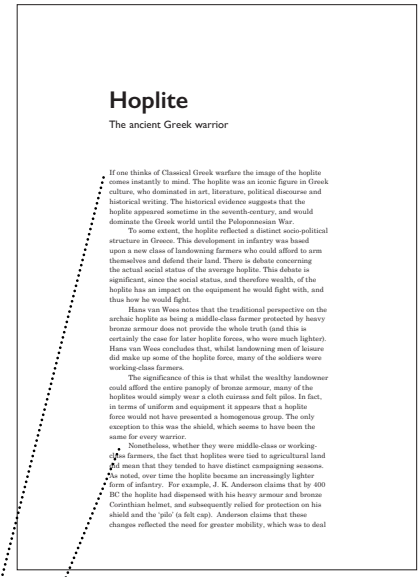
To some extent, the hoplite reflected a distinct socio-political structure in Greece. This development in infantry was based upon a new class of landowning farmers who could afford to arm themselves and defend their land. There is debate concerning the actual social status of the average hoplite. This debate is significant, since the social status, and therefore wealth, of the hoplite has an impact on the equipment he would fight with, and thus how he would fight.

Hans van Wees notes that the traditional perspective on the archaic hoplite as being a middle-class farmer protected by heavy bronze armour does not provide the whole truth (and this is certainly the case for later hoplite forces, who were much lighter). Hans van Wees concludes that, whilst landowning men of leisure did make up some of the hoplite force, many of the soldiers were working-class farmers.

The significance of this is that whilst the wealthy landowner could afford the entire panoply of bronze armour, many of the hoplites would simply wear a cloth cuirass and felt pilos. In fact, in terms of uniform and equipment it appears that a hoplite force would not have presented a homogenous group. The only exception to this was the shield, which seems to have been the same for every warrior.

Nonetheless, whether they were middle-class or working-class farmers, the fact that hoplites were tied to agricultural land did mean that they tended to have distinct campaigning seasons. As noted, over time the hoplite became an increasingly lighter form of infantry. For example, J. K. Anderson claims that by 400 BC

practice



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Paragraphs denoted by one line space (no indent) are significantly superior than paragraphs denoted only by a new line, but not superior than paragraphs denoted by a new line with an indent.

[Hartley et al, 1978]

Readers favour paragraphs denoted by indentation and additional line space.

[Schriver , 1997]

The first paragraph in an article, chapter, or advertisement should have no indent.

[Simon, 1945; Tschold, 1967; Carter et. al, 1993]

In books, magazines and newspapers, paragraphs should be denoted with a moderate indentation of one to three ems, or separated by one line space.

[Hartley and Burnhill , 1977a; Rehe, 1979; Bringhurst, 1992; Carter et al, 1993;Hartley, 1994]

Paragraphs separted by one line space should be avoided when text is composed mainly of short paragraphs.

[Carter et al, 1993]

Typographic Features of Text: Outcomes from Research and Practice

2

Maria dos Santos Lonsdale

ABSTRACT:

This paper presents a comprehensive review of literature on the legibility of printed text in order to provide informed guidance on the design and preparation of typographic materials. To this end, experimental findings are taken into account, as well as the perspective of typographers, graphic designers, and authors. First, the typographic features of text are reviewed and illustrated individually to identify all the features that specifically characterise text layouts. It is emphasized, however, that the various typographic features should be selected in relation to each other, and that it is the combination and manipulation of all these typographic features as a group that makes the text legible. Studies are then reviewed and illustrated on the typographic structure of text as a whole. This information will prove useful to anyone involved in the development of typographic materials, including typographic and graphic designers, teachers and students.

KEYWORDS:

typographic features of text, text structure, legibility, typography, reading performance

1. INTRODUCTION

A comprehensive review of studies on the legibility of text is extremely useful to practitioners, researchers, and scholars, particularly when users' reading performance is the primary concern. A literature review of this nature will confirm (or dismiss) many established conventions regarding the typographic design of text. It will also help practitioners to make educated choices and produce user-orientated design outcomes. Moreover, it will give practitioners solid evidence to justify their design decisions.

Therefore, the purpose of the present paper is to draw attention specifically to the legibility of printed text. Legibility is here interpreted as the speed and accuracy with which text on a page can be read. This interpretation is in agreement with Pyke's (1926) own definition, as well as Zachrisson (1965, 36) and Reynolds' (1978, 197) opinions.

It has been argued that many typographic practices impair rather than help legibility. For example, Hartley and Burnhill (1976) have analysed and pointed out several poor typographical practices.

> Amongst these are: the centring of headings and other textual components; the practice of changing arbitrarily the internal spacing of the material in order to force the text to fill out a fixed width and depth ("justification"); inconsistency in the sequencing and the grouping of parts; excessive use of indentation in texts which do not consist simply of pages of information arranged in paragraph form; and excessive variety of sizes, styles and weights of typeface chosen to code heading levels. (Hartley and Burnhill, 1976, 100)

They go even further by arguing that these practices could "justifiably be termed "illiterate" for, clearly, parts of a text are not mere objects of varying shapes and sizes to be arranged like ornaments on a mantelshelf or pictures on a wall." (1976, 100). After illustrating these poor typographic practices through examples of *British Psychological Society Publications*, Hartley and Burnhill (1976) propose that fundamental re-thinking is required. This observation, therefore, leads to the hypothesis that the speed and accuracy of reading text may be affected by various typographic features (from the typeface used to the treatment of paragraphs, etc.).

Unfortunately, there are only a few studies on the structure and articulation of information on the page as a whole, i.e. studies that test the effects of combined typographic features on reading. For this reason, this paper starts by reviewing the typographic features of text individually. Referring to each typographic feature individually allows us to identify all of the features that specifically characterise text layouts and which one may have a bigger effect on performance. The few studies on the typographic structure of text as a whole are then reviewed.

This review also takes into account experimental findings as well as the perspective of typographers, graphic designers,

and other authors. Scientific approaches do not always reach the same conclusions as the views of practitioners and other authors. However, for a well-founded review, it makes sense to link scientific research and practice (Lupton, 2004; Hartley et al, 2006; Lonsdale *et al*, 2006; Lonsdale 2006; Beier, 2012; Dyson, 2013; Beier and Dyson, 2014). In the first instance, this allows us to identify the level of agreement between scientific studies and practice. In the second, we can identify how one approach can be used to inform and complement the other. For example, typographic practice can inform the selection and design of the experimental material. Moreover, in those situations where scientific studies are unable to give clear answers, typographic practice can help in deciding how typographic features can be manipulated to produce legible typographic materials.

2. STRUCTURE OF THE PAPER

The present literature review is limited to what is considered relevant and useful to the typographic structure of reading text in common real- life situations. With this aim in mind, this review includes research and opinions considering those design choices that might cause or prevent an unwanted effect on readers. Regarding experimental findings, this review includes studies:

- having adults as participants who regularly read books, articles, technical manuals, etc.;
- testing printed documents with a sufficient number of words to represent standard reading documents such as passages, articles, etc.;
- placing the material to be read at ordinary distances of approximately 300-350mm from the eyes;
- measuring legibility by the speed and/or accuracy of reading, as well as the readers' preference judgements.

Exceptions to this are mentioned throughout the review. However, studies related to people with impaired vision, studies focusing on writing rather than reading, and on-screen legibility studies are excluded as they have no direct relevance to this literature review.

As for the grouping of research findings and opinions according to the typographic features of text, different approaches have been taken thus far (e.g. Zachrisson, 1965; Reynolds, 1978; Wijnholds, 1997; Hartley, 2004). For the purpose of this paper, Twyman's model of verbal graphic language (Twyman, 1982, 11-6) will be followed. Twyman presents a clearly structured model with a theoretical explanation, where a distinction is made between intrinsic and extrinsic features. Intrinsic features are described as those that reside in the characters themselves and, more particularly, in the system that produces those characters (for example, manuscript as opposed to typeset). Examples of intrinsic features are size and style of letterforms, including the use of italic, bold, and small capitals

(i.e. capital letters of a typeface in smaller size that are redrawn to match the x-height and weight of lowercase letters). Extrinsic features relate to what can be done to those characters or sets of characters by changing their colour, controlling the space between them, or changing their configuration. Twyman further distinguishes spatial features at the micro level – in relation to intercharacter space, interword space or the position of subscripts and superscripts – and also at the macro level – in relation to the spacing of larger units of text.

This approach is used to group and discuss the literature on the typographic features of text in Sections 3 and 4. The combination and manipulation of the various typographic features that can make clear (or unclear) the structure of text is then addressed in Section 5.

At the end of almost every section a summary table presents the main advice that has emerged from research and practice. An example is also provided in parallel to illustrate and sometimes compare approaches. Section 6 presents a comprehensive summary table, which lists all of the empirical studies referred to in this paper, and grades their validity taking into account the parameters described below.

3. INTRINSIC FEATURES

3.1. TYPEFACE CHOICE

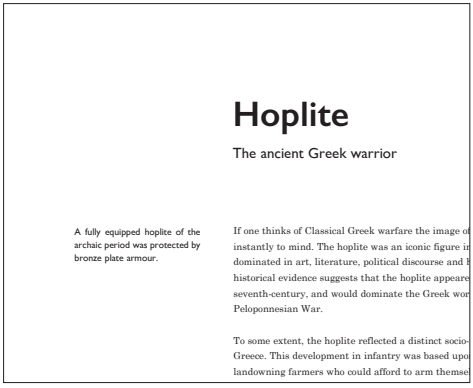

FIGURE 1.

Main text in serif, heading and caption in sans serif.

Choosing a typeface according to its legibility has been a primary concern of many designers (both typographic and graphic) when the main purpose of the text with which they are working is continuous reading. This choice has also formed the basis for experimental studies and has been widely discussed.

Three experiments measuring speed of reading have reported findings of no significant differences between typefaces in common use. One example of no significant differences between typefaces is Paterson and Tinker's (1932) test to identify which typefaces could be read most rapidly. The speed of reading for each of the six typefaces in common use at that time (Garamont, Antique, Bodoni, Old Style, Caslon Old Style, and Cheltenham) was compared with Scotch Roman (another commonly used typeface). The choice was based mainly on the opinions of a large number of editors and publishers. All typefaces were set in 10-point size, 19-pica line length (about 52 characters – Scotch Roman), and set solid (in text that is set solid, the interlinear space is equal to the point size of the type). The results showed that the six typefaces did not differ significantly from Scotch Roman. The study further included three radically different typefaces from the ones

in common use. In this case, however, two of these typefaces (American Typewriter and Cloister Black – Old English) were read more slowly than Scotch Roman. The modern typeface Kabel Lite was practically as legible as Scotch Roman. (A description of this test can also be found in Tinker's book *Legibility of Print*, 1963.)

Another example is Pyke's (1926) study testing the legibility of eight typefaces (referred to by, for example, Tinker, 1963a, 51; Cornog and Rose, 1967, 302-4; Lund, 1999, 102-5). Although Old Style No. 2 seemed the most legible and Modern Condensed No. 39 the least legible typefaces, Pyke considered the differences to be small. He concluded that typefaces used in everyday reading situations, if well printed, do not produce significant differences in legibility. Burt (1959) also conducted an investigation to determine the relative legibility of ten different book faces that were in common use at that time. However, Burt's practices and contributions are considered dubious. (see Lund, 1995 and 1999, and Hartley and Rooum, 1983, for further discussion), mainly due to concerns about whether the data were used to support a predetermined position.

Readers' preference judgement is another measure that has also been considered when researching the legibility of typefaces. Tinker (1963a, 49-50) concluded from the combined judgements of participants on the typefaces used in Paterson and Tinker's study in 1932 that readers do have preferences for typefaces, but that preferences do not always coincide with readers' performance when reading their preferred typeface.

Recommendations supported by practice have been made for how to choose an effective typeface. Simon (1945, 11) and later Hartley (1994, 32; 2004, 920), suggest that the purpose of the text should be taken into account. In agreement with Black (1990, 12-3), Hartley (1994, 32; 2004, 920) further recommends the avoidance of those typefaces with unusual features which may create irregularities in the text and confuse readers. Furthermore, typefaces which may lose their identity when printed or copied should also be avoided: typefaces with fine lines which may break down; typefaces with small internal spaces which may fill in; typefaces with a strong contrast between thick and thin strokes which may cause a dazzle effect; and typefaces in which the letters appear to touch one another. (See also Simon, 1945, 11-21, and Bringhurst, 1992.) Luna (1992, 74-6) adds to this the opinion that a typeface that calls attention to itself rather than to the text should not be chosen; nor a typeface that is based on tradition without its appropriateness having been tested more objectively.

The comparative legibility of serif and sans serif type should also be considered when choosing a typeface. Luna (1992, 74) argues that "traditional seriffed typefaces are rarely unsuitable for continuous reading, and that few sans serif are appropriate for this purpose." From studies that have compared the legibility of these two distinctive categories, no definitive conclusion has been reached. (See extensive research and conclusions of Lund, 1999.) Serif and sans serif typefaces are likely to be read equally quickly and accurately.

Examples of experiments measuring speed of reading and comprehension that have not shown a significant difference in legibility between serif and sans serif typefaces are Paterson and Tinker's study (1932) mentioned above and Moriarty and Scheiner's (1984) experiment measuring how many words were read in a given time period (the serif typeface Times New Roman and the sans serif typeface Helvetica were tested).

However, suggestions are also made that sans serif typefaces whose rhythms and spacing relate closely to those of serif typeface seem most satisfactory for continuous text (Lund, 1992, 74). In fact, it is interesting to note that some studies have found a significant difference between sans serif typefaces, despite there being no significant difference between serif and sans serif typefaces. In a study measuring rate of comprehension, Poulton (1965) found that the sans serif typeface Gill medium produced a reliably greater rate of comprehension than all the other sans serif typefaces tested (although it was not reliably better than any of the serif typefaces). Poulton attributed this result to the fact that Gill, with its geometrical approach allied to humanistic letterforms, has a stronger character differentiation than the other sans serif typefaces.

Readers' preferences have also failed to clearly distinguish between serif and sans serif typefaces. For example, Schriver and colleagues (Schriver, 1997, 288-303) conducted a study on typeface preferences using complete texts that reflected the sorts of documents people read in everyday contexts. Four different materials were assessed: a microwave manual, a credit letter, a tax form, and a short story. Each document was designed using four different serif typefaces and four different sans serif typefaces. To avoid confounding typeface legibility with differences in x-heights, Schriver and colleagues employed a larger type size in the serif versions of the documents. Although the results suggested that serif or sans serif typefaces are equally likely to be preferred, they also suggested that serif type might be better when reading continuous prose and sans serif type when reading instruction manuals. Schriver and colleagues then concluded that the situation in which reading is taking place might well influence readers' preferences.

In the 1930s, Tschichold (1967) strongly defended the use of sans serif, claiming that it "is so simple and clear that it is by far the best all-purpose type for today and will remain so for a long time to come…" (1967, 28). However, for the purpose of continuous reading, Tschichold accepted the use of serif to be appropriate. More recent opinions have favoured the use of both serif and sans serif in the same document. Serif type could be used for the body of the text (e.g. McLean, 1980; Schriver, 1997), which is in agreement with Luna's opinion referred to above, and sans serif could be used for headings, captions and marginalia (e.g. Simmonds and Reynolds, 1994, 46; Schriver, 1997).

The lack of clarity in these findings and the assumptions made suggest that Carter *et al* (1993, 88) may well be right when

TABLE 1.

Typeface

Research	Practice
• Typefaces used in everyday reading situations, if well printed, do not produce significant differences in legibility [e.g. Pyke, 1926 (described in Tinker, 1963a); Paterson and Tinker, 1932]	• Avoid typefaces: with unusual features; which may lose their identity when printed or copied; which call attention to themselves rather than to the text; which have not been tested objectively. [Simon, 1945; Hartley, 1994 and 2004; Black, 1990; Luna, 1992]
• No distinctive difference between serif and sans serif type in speed of reading and comprehension. [e.g. Paterson and Tinker, 1932; Poulton, 1965; Moriarty and Scheiner, 1984]	• Use serif for continuous prose and for the body of the text. [e.g. McLean, 1980; Schriver, 1997]
• No clear preference for either serif or sans serif type. [e.g. Schriver, 1997]	• Use sans serif for instruction manuals, headings, captions, and marginalia. [e.g. Simmonds and Reynolds, 1994; Schriver, 1997]

claiming that other typographic features seem to be far more important in the reading process than the selection of either a serif or a sans serif typeface.

3.2. TYPE VARIANTS

3.2.1. Italic

Studies have been carried out exploring the use of italic in continuous prose instead of roman lowercase characters, and have shown that the use of italics retards reading. One example is Tinker's (1955) experiment using prolonged reading tasks. Tinker's study showed that reading speed was substantially reduced when reading italic (a retardation of 15.5 words per minute). The material used included two forms set in 10-point type in a 20-pica line length (about 55 characters per line) with 12-point interlinear space. The only difference was that one form was set in Excelsior roman and the other in Excelsior italic type. Another example is Tinker and Paterson's (1928) study where italic text was read 2.8 per cent slower than lowercase text. As for preferences, in another study carried out by Paterson and Tinker (1940, described in Tinker, 1963a, 54-6), 96 per cent of the participants judged that roman lowercase could be read more easily and faster than italic.

In addition, when we analyse documents in current use, we can see how italic is frequently applied to distinguish elements in a text: for example, titles of books in bibliographies, foreign words, abstracts in journal articles, etc. (as referred to by Simon, 1945, 5; Glynn *et al,* 1985; Carter *et al*, 1993, 91; Gilreath, 1993; Hartley, 1994, 30, and 2004, 921; Simmonds and Reynolds, 1994, 65-6; Schriver, 1997, 266). Thus, despite some authors' claims that bold should be used instead of italic for differen-

tiation in text matter (e.g. Rehe, 1979, 31), the common practice of using italic for differentiation is likely to be more appropriate. At least in certain situations, readers may well prefer italic over bold because of its conventional use.

3.2.2. Bold

FIGURE 2.

Italic or bold to distinguish elements [top]. Bold for black background [bottom].

Some researchers have explored the weight of a typeface in an attempt to define the optimum degree of boldness for reading. Luckiesh and Moss (1940) examined the speed of reading Memphis typeface in four weights: light, medium (20 per cent greater boldness than light), bold (35 per cent greater boldness than light) and extra bold (69 per cent greater boldness than light). Text was set in 10-point type Memphis with 2 points of leading and a line length of 21-pica (about 53 characters for Memphis medium). There was no significant difference in speed of reading, measured by the number of lines of text read during a period of five minutes of continuous normal reading. However, the medium and bold settings produced the highest reading speeds (an improvement of only three per cent).

Tinker and Paterson's (1942) study also failed to find any difference when participants read continuous text at a normal distance. Both weights, i.e. standard and bold, were read at the same rate. The text was printed in 10-point Scotch Roman type, 19-pica (about 52 characters) line length and set solid. As for judgements, a different group of 224 participants thought that standard type was more legible and pleasing than bold face.

Readers' judgements, therefore, seem to correspond to the opinions of authors who suggest that for continuous text a typeface of medium weight, not too heavy or too light, should be employed (e.g. Rehe, 1979, 31). Nonetheless, bold can be very effective to emphasise one piece of information over another (e.g. Reynolds, 1978, 199; Rehe, 1979, 31; Bringhurst, 1992, 52; Carter *et al*, 1993, 91; Schriver, 1997, 267-8; Wijnholds, 1997; Strizver, 2014), or as a technique to thicken the lines of characters that will be printed in pale ink, or on a black or coloured background (Bringhurst, 1992, 52). Because bold type draws attention, this variant is best used for specific situations that require emphasis. So, for example, it can be used to distinguish words (e.g. 'not', 'NB') or headlines, rather than whole sentences. But because bold has different weights (bold, semi-or demi-bold, black or ultra) from which we can choose, care should be taken when using bold for emphasis where the aim is to create enough contrast. A slight difference in weight will be ineffective and can actually look like a print error.

TABLE 2.

Type variants: italic and bold

Research	Practice
• When compared to roman lowercase text, italic retards reading. [e.g. Tinker and Paterson, 1928; Paterson and Tinker, 1940 (described in Tinker, 1963a); Tinker, 1955]	• Use italic to distinguish elements in a text. For example: titles of books (in bibliographies), foreign words, abstracts in journal articles. [e.g. Simon, 1945; Glynn *et al*, 1985; Carter *et al*, 1993; Gilreath, 1993; Hartley, 1994 and 2004; Simmonds and Reynolds, 1994; Schriver, 1997]
• Both medium and bold text are read at the same rate. [Luckiesh and Moss, 1940; Tinker and Paterson, 1942]	• Bold can be very effective to emphasise one piece of information over another. [e.g. Reynolds, 1978; Rehe, 1979; Bringhurst, 1992; Carter *et al*, 1993; Schriver, 1997; Wijnholds, 1997]
• Readers consider medium type more legible and pleasing than bold type. [Tinker and Paterson, 1942]	• Bold can be used as a technique to thicken the lines of characters that will be printed in pale ink, or on a black or coloured background. [Bringhurst, 1992]

3.3. ALL-CAPITALS VERSUS LOWERCASE

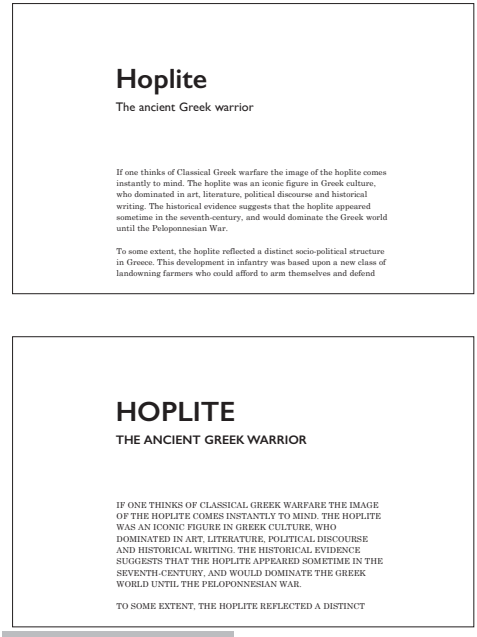

FIGURE 3.
Main text in lowercase [top] and all-capitals [bottom].

It has been argued that lowercase is easier to distinguish and recognise than all capitals (e.g. Rehe, 1979, 35-6; Humphreys and Bruce, 1989, 329). In fact, studies have shown that lowercase is read more rapidly than all-capitals: in Tinker and Paterson's (1928) study lowercase was read 13.4 per cent faster; in Tinker and Paterson's (1942) study lowercase was read 11.8 per cent faster; and in Tinker's (1955) study lowercase was read 10.2 to 14.2 per cent faster.

Another study, carried out by Poulton (1967), showed that readers located newspaper headlines printed in bold lowercase more quickly than headlines in all-capitals. The x-heights of the bold lowercase letters were approximately the same as the heights of the capital letters. In addition to the finding that lowercase is read more rapidly than all-capitals, Tinker and Paterson (1942) further found that readers judged lowercase as more legible and pleasing. As all continuous

reading involves more lowercase (Tinker and Paterson, 1928, 366-7 and Tinker ,1963a, 61), lowercase might be more familiar to readers, i.e. readers had more practice with it.

This evidence for the superiority of lowercase led to the conclusion that all-capital printing should be avoided whenever rapid reading is required or when readers' preferences are the main concern (Tinker, 1963a, 61; Rehe, 1979, 36). Instead it is proposed that both capitals and lowercase letters should be used, reserving the capitals for the initial letter of nouns, sentences, and headings (Poulton, 1967; Hartley and Burnhill, 1977a, 71). The use of all-capitals for main headings, or small capitals for secondary headings, may be satisfactory because such headings are normally surrounded by space, which helps in their visual distinction (Hartley, 2004, 921). Opinions expressed by Tschichold (1967, 34 and 38), Black (1990, 16 and 30), Carter *et al* (1993, 89), Simmonds and Reynolds (1994, 66), Schriver (1997, 274), Hartley (2004, 921) agree with the research findings described above.

Another interesting argument is the fact that lowercase occupies less space than all-capitals of the same body size (Hartley and Burnhill, 1977a, 71; Black, 1990, 16), about 35 per cent less (Tinker 1963a, 60; Carter *et al*, 1993, 89). This results in economy of space.

TABLE 3.

All-capitals versus lowercase

Research	Practice
• Lowercase is read more rapidly than all-capitals. [e.g. Tinker and Paterson, 1928; Tinker and Paterson, 1942; Tinker, 1955; Poulton, 1967]	• Both capitals and lowercase letters should be used, reserving the capitals for the initial letter of nouns, sentences and headings. [Poulton, 1967; Hartley and Burnhill, 1977]
• Readers prefer lowercase. [Tinker and Paterson, 1942]	• Lowercase occupies less space than all-capitals of the same body size, about 35 per cent less. [e.g. Tinker, 1963a; Hartley and Burnhil, 1977a; Black, 1990; Carter *et al*, 1993]

3.4. TYPE SIZE

In metal type the size of type is conventionally expressed in points, i.e. the measure of the whole body of the metal block for the letterform including ascenders, descenders, and the extra space at the top and bottom that is required to create space between successive lines of type. However, different typefaces with the same type size vary in their x-heights (the top-to-bottom dimension of a lowercase "x"). Several researchers have argued that point size terminology is an unsatisfactory measure for research since it does not specify the actual size of the printed typeface (Poulton, 1965, 350-60; Poulton, 1969, 58; Hartley *et al.,* 1975, 115-6; Hartley, 2004, 919-20).

This is clearly illustrated by the results of Poulton's study (1972) comparing the legibility of three typefaces, i.e. number of target words found in a list of food ingredients. When all typefaces were printed in the same point size, differences of legibility were found, but when the x-height of all three was equated to approximately the same size, no difference was found. Typographers (e.g. Simon, 1945, 13), designers (e.g. Carter *et al.,* 1993, 90), and other authors (e.g. Rehe, 1979, 27-9) seem to agree with these results. Some go even further by claiming that typefaces with greater x-heights can be set at a smaller size than typefaces with smaller x-heights without losing legibility (e.g. Schriver, 1997, 258-9). (See also Legge and Bigelow, 2011, for a discussion of x-height and a thorough review of findings from vision science and typography regarding type size.)

Sizes of type, however, have also been frequently defined by measuring the body size of the type and not the x-height (as reported below). Therefore, it is important to keep in mind that when choosing a typeface according to its body size, the same designated type sizes will not, in fact, look the same size.

The most regularly used type sizes, between 9-and 12-point, are regarded as being the most legible for text intended to be read at normal reading distances of 12-to 14-inches, i.e. about 300 to 350 millimetres (e.g. Tinker, 1963a, 69-73; Spencer, 1969, 35; Rehe, 1979, 29; Carter *et al,* 1993, 90). Furthermore, 10-or 11-point are suggested as the optimum sizes with the caveat that it depends on the typeface (e.g. Tinker 1963a, 71; Reynolds, 1978, 200). These suggestions and results concern both speed of reading and preference judgements. It is also noted that smaller sizes such as 6-or 8-point type are often used in legal documents, but these can be too small to read easily. Larger sizes of 14, 18-and 24-points are often used for headings and display purposes (Hartley, 2004, 919).

Although type size may have a strong influence on legibility, it has been argued that it is best not to consider type size separately. For example, after describing one of his extensive studies with Paterson (Paterson and Tinker, 1929) on the influence of type size on legibility of print in a chapter devoted to *Size of type*, Tinker (1963a, 69-72) discarded the data as inconclusive. In the study, speed of reading was measured comparing 6-, 8-, 12-, and 14-point type to the standard 10-point type (an illustration can be found in Tinker, 1963a, 70). The results do not seem unreasonable: texts in 6, 8, 12 and 14-point type were read significantly more slowly than 10-point type. The difference ranged from 5.2 to 6.9 per cent. However, line length and interlinear space were kept constant while type size varied. Tinker, therefore, concluded that:

> … line width, leading, and type size must be coordinated in any final judgement concerning the legibility of type size. All three factors should be studied under conditions where simultaneous and systematic variations of all three are made. (Tinker, 1963a, 73)

Others that agree with Tinker's view include Zachrisson (1965, 39), Reynolds (1978, 200), Rehe (1979, 29-30), Schriver (1997, 263), and Wijnholds (1997). Scientific evidence (Skottun and Freeman, 1983) has further shown, however, that the space between letters also affects how size of type is perceived. Therefore, interletter space should also be coordinated with type size before any conclusion can be reached on legibility.

4. EXTRINSIC FEATURES

4.1. COLOUR

4.1.1. Type and background colour

It is acknowledged that the relationship between type and background colour is another important factor for legibility. Michael and Jones (1955) conducted a meticulous study to determine the extent of differences in the average scores of students when presented with examination papers on different colours of paper. Different colours of paper were selected and randomly presented to participants. This selection took into account, for example, the complaints of faculty members and students on the unpleasant aesthetic qualities of yellow-orange paper. Results were straightforward in showing that colour of paper did not significantly affect the average number of correct answers.

Aside from the legibility of type on coloured backgrounds for examination papers, other studies have been carried out which are reviewed, described, and discussed by Tinker (1963a, 137-51) in his book *Legibility of Print* (e.g. Tinker and Paterson, 1931 and Luckiesh and Moss, 1938). The studies tested the speed of reading: black text on coloured paper, black on white versus white on black arrangements, and coloured type on coloured paper. In summary, the results from all the studies indicate that black print on a white background is much more legible than white print on a black background for materials to be read in an ordinary situation. On this basis, Tinker concludes that if white type on black is employed to attract attention, the amount of text should be small, and a sans serif type in 10 to 14-point size should be used to minimise the loss of legibility. Readers also prefer to read black on white, rather than white on black. It is further concluded that it is possible to coordinate coloured print with coloured paper so that legibility and 'pleasingness' are maintained at a satisfactory level.

Supported by references to empirical research, Hartley (2004, 921) notes that black ink on white or yellow paper is generally preferable to red ink on these colours, and that black ink on dark red or purple paper is generally to be avoided.

4.2. MICRO SPACING

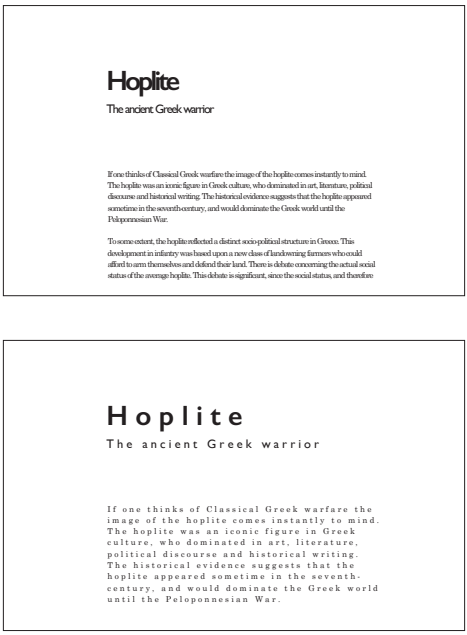

FIGURE 4.

Interletter space: too narrow [top]; too wide [bottom].

Although interletter and interword space also seem to affect legibility, limited experimental evidence is available on this matter. One of the few examples is the investigation carried out by Spencer and Shaw in 1971. The aim of the study was to find out whether variation in interletter space (close, average and wide spacing) for the sans serif type Gill Sans affected the legibility of continuous printed text. The results showed that reading speed and comprehension were the same for all the kinds of spacing tested. However, from the illustrations provided it is clear that the narrowest setting is too close to the point of making the letters collide with each other and, consequently, causes a significant decrease in legibility. We should also be aware that the same percentage of space reduction might have different effects on the legibility of other type sizes and other typeface designs. This may be the case, for instance, with a serif typeface where serifs might touch with the same interletter space for a sanserif typeface that does not touch.

A more recent study conducted by Chung (2002) has shown that reading speed is at its peak with standard letter spacing, and decreases for both smaller and larger letter spacing. As later found and explained by Yu *et al* (2007), with extra wide spacing, reading becomes slower because the size of the visual span (the number of letters recognized with high accuracy without moving the eyes) becomes smaller. However, in these studies the text was presented on a computer monitor. Therefore, these results are only used in this paper for theoretical reflection.

Opinions expressed by authors and practitioners indicate interletter space that is too wide disrupts the reading process since the readers are forced to read the letters individually. Moreover, extreme interword space also creates vertical white spaces that look like rivers running down the page, which destroys the normal page texture. This is especially apparent in newspapers where text is fully justified, resulting in inconsistent interword and interletter spacing. On the other hand, with space that is too narrow, the letters and words join together and readers have more difficulty in recognising adequately each individual letter and word. All these issues should be considered (Simon, 1945, 30; Tschichold, 1967, 37-8; Black, 1990, 17-8 and 39-41; Carter *et al,* 1993, 89-90), especially when the information has to be taken in at a quick glance (Hartley and Burnhill, 1977a, 69).

Therefore, where quick reading seems to be the first concern, it is definitely wiser to avoid setting the type too wide or too

close. However, research and practice are yet to give us quantifiable definitions for 'too wide' and 'too close'. Based on the studies reported above, it seems that for a 10 to 12-point type size, 'too wide' letter spacing would correspond to an overall space character above a "thick" space (1/3 the width of an em). An 'em' is defined by Simmonds and Reynolds (1994, 173) as the width of a lowercase letter 'm'. 'Too close' letter spacing would correspond to an overall space character below a "thin" space (about 1/5 to 1/8 of an em). In fact, type in smaller sizes, lighter weights, and expanded style can actually benefit from wider letter spacing. Type in larger sizes, heavier weights, and condensed style can also benefit from closer letter spacing.

TABLE 4.

Interletter and interword space

Research	Practice
• Reading speed is not affected when interletter space is changed slightly. [Spencer and Shaw, 1971]	• Interletter space that is too wide or too narrow disrupts the reading process. [e.g. Simon, 1945; Tschichold, 1967; Black, 1990; Carter *et al*, 1993] • Extreme interword space creates vertical white spaces that look like rivers running down the page, which destroys the normal page texture. [e.g. Simon, 1945; Tschichold, 1967; Black, 1990; Carter *et al*, 1993]

4.3. MACRO SPACING

4.3.1. Alignment

Type set fully justified seems to represent a more traditional approach (Luna, 1992, 640). In fully justified setting the space between words is inconsistent in order to fill the width of the column (as mentioned above, newspapers are a good example of justified setting with clearly inconsistent word spacing). Conversely, text aligned on the left and ragged right creates consistent word spacing and has become an increasingly popular practice (Gregory and Poulton 1970, 427; Reynolds, 1978, 203, Luna, 1992, 64).

Unlike right alignment and centred text, the effect of full justification and left alignment on the legibility of text has been the subject of a number of studies (e.g. Zachrisson, 1965; Fabrizio *et al,* 1967; Becker *et al,* 1970; Gregory and Poulton, 1970; Hartley and Burnhill, 1971; Hartley and Mills, 1973; Wiggins, 1977). When comparison was made between the two type settings, no differences in reading times were found when a medium line length was used.

Of the studies comparing full justfied and left aligned text, Gregory and Poulton's study (1970) is the most clearly

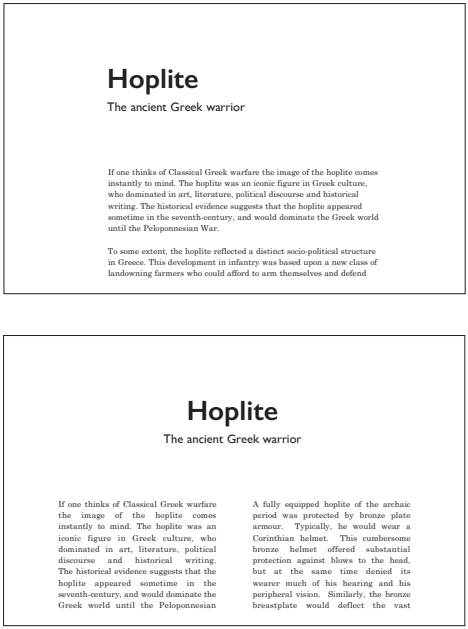

FIGURE 5.

Left aligned text [top]. Justified text with rivers [bottom].

articulated. It also contains a clear attempt by the researchers to maximise the sensitivity of the study (Gregory and Poulton, 1970, 428). A comparison was made between the rate of comprehension when reading passages presented in three different styles – fully justified, left aligned with hyphenated words (i.e. broken words), and left aligned with no hyphenated words. All passages were printed in one style only and set in 9-point type with 10-point interlinear space and in a line with a maximum length of seven words per line, about 42 characters (a single narrow column). To confirm some of the findings of this first experiment, Gregory and Poulton conducted two additional experiments with some adjustments, including an increase in the line length from an average of seven words per line to twelve words per line (about 70 characters). Over the whole study, the alignment of text made no difference for good readers, but for poor readers the fully justified style resulted in significantly worse performance when reading the shorter lines of seven words. Zachrisson (1965, 145-55), in an earlier study, had also cited evidence that left aligned text is read more quickly by less proficient readers when the lines are, on average, 9 words (about 52 characters).

A study carried out on readers' preferences for typeface, alignment and interlinear space by Becker *et al* (1970) showed no differences in preferences for fully justified or left aligned text. The researchers concluded, however, by saying that definitive conclusions could not be drawn since the number of participants was small (ten), and that it was hard to say how far the findings could be generalised for other typefaces or situations.

As no definitive conclusions have been reached with these studies concerning the alignment of text, it seems that the real issue here has more to do with interletter and interword space than with the alignment of text. As Schriver (1997) concluded, "Justifying the text or not is probably the wrong concern. The right concern is how to achieve a text without rivers and excessive hyphenation." (1997, 270). Rivers can be prevented by aligning text to the left or by avoiding short line lengths. However, if justification has to be used, then a consistent texture can be achieved by hyphenating at the ends of lines whenever possible (Carter *et al,* 1993, 93). Further practical considerations of hyphenation on the legibility of text are given by Bringhurst (1992, 40-1) and Luna (1992, 58-66).

Hartley and Burnhill (1971) compared various settings of standard left aligned text (i.e. with no hyphenated words at the end of the text lines) and left aligned text with a moderate hyphenation (i.e.

where 33 per cent of the text lines end with hyphenated words). No differences were found between them in the number of words read. However, after showing the differences between the typographic layouts to the subjects, 24 preferred the standard left aligned version against 10 that preferred the hyphenated version, while 8 subjects had no preference. This suggests that, if readers' preferences are to be taken into account, hyphenation should be used sparingly, or not used at all.

TABLE 5.

Alignment

Research	Practice
• No difference in performance between fully justified or left aligned text with a medium line length. [e.g. Zachrisson, 1965; Fabrizio *et al*, 1967; Becker *et al*, 1970; Gregory and Poulton, 1970; Wiggins, 1977]	• Reading is disrupted when text is fully justified, with rivers and excessive hyphenation that disrupts reading. [Carter *et al*, 1993; Schriver, 1997]
• No difference in preferences for fully justified or left aligned text. [Becker *et al*, 1970]	

4.3.2. Line length

Driven by technology, different measures have been used for line length (sometimes called line width). These include ems, picas, points, millimetres, and inches. To avoid confusion, some authors have described line length in terms of the average number of characters per line (e.g. Spencer, 1969, 35). Other authors have explicitly recommended checking the number of characters and spaces as a practical expedient, rather than using a linear measurement (e.g. Reynolds, 1978, 201;and Wijnholds, 1997). Each letter, numeral, punctuation mark, and space is considered a 'character' (Simmonds and Reynolds, 1994, 48). However, studies rarely describe line length as the average number of characters and spaces per line. Since characters-per-line is a more precise unit of measure, in this paper all line length measures were converted into an approximate number of characters per line.

As previously discussed, it is generally accepted that an optimal typographic arrangement is dependent upon the simultaneous variation of type size, line length, and interlinear space for any final judgement concerning the legibility of type. However, the few available studies conducted to test the effects of line length on legibility did not consider the three variables together (except for some studies carried out by Tinker and Paterson which are discussed in the next section).

For example, Wiggins (1977) tested only one or two variables at the same time. In one experiment, line lengths of 10-, 11-

and 12-picas (about 26, 29 and 33 characters respectively) were tested in combination with three different typefaces and a 10-point type size (the x-height varied). In a second experiment, line lengths of 10-, 14-, 19-, 24-, and 29-picas (about 26, 39, 52, 65 and 78 characters respectively) were tested using constant and variable space between words for 10-point size in order to produce uneven and even right margins, accordingly. Wiggins (1977) found that lines of medium length were read faster than the shorter and longer lines. The 12-pica line was read faster than 10-and 11-pica lines when averaged over three different typefaces; the 14-pica line was the optimum for constant interword space; and the 19-pica line was the optimum for variable space. Thus, it seems that in all cases moderate line lengths were read faster than shorter or longer line lengths.

Tinker (1963a, 86) also reports that readers favour moderate line lengths. This advantage of moderate line length over short or long line length, for both reading speed and preference, seems to be for two distinct reasons. First, more fixation pauses of greater duration seem to be employed when reading very short line lengths than when reading moderate line lengths (e.g. Tinker, 1963a, 86). Moreover, with very short line lengths the readers have to change lines too frequently, thus making inefficient use of their peripheral vision when reading (e.g. Simmonds and Reynolds, 1994, 48). The number of hyphenations is also greater with very short line lengths than with moderate line lengths. Second, with very long line lengths it is more difficult for the eyes to make an accurate return sweep, i.e. a long movement to the left from the end of a given line to the beginning of the next line (e.g. Luna, 1992, 54; Carter et al, 1993, 90; Simmonds and Reynolds, 1994, 48; Schriver, 1997, 263; Wijnholds, 1997). Consequently, several fixations may be required before the correct line is found (e.g. Simmonds and Reynolds, 1994, 48) and the number of regressions after the return sweep of the eyes may be greatly increased, which leads to less efficient reading (e.g. Tinker, 1963a, 86).

According to Spencer's (1969, 35) review of scientific studies, the optimal line length seems to be between ten to twelve words, or 60 to 70 characters per line. Opinions of both authors and practitioners concur with this recommendation (Simon, 1945, 7; Tschichold, 1967, 40; Lewis, 1963, 57; Rehe, 1979, 30; Black, 1990, 43; Bringhurst, 1992, 26-7; Carter *et al*, 1993, 91; Simmonds and Reynolds, 1994, 48; Schriver, 1997, 263; Wijnholds, 1997).

4.3.3. Interlinear space and relationship with type size and line length

Interlinear space is used in this paper as a term to describe 'baseline to baseline measurement', i.e. the amount of vertical space placed between the baseline of one text line and the baseline of the next, and is expressed in points. (As mentioned above, in text that is set solid the interlinear space is equal to the point size of the type.) Interlinear space has also been described

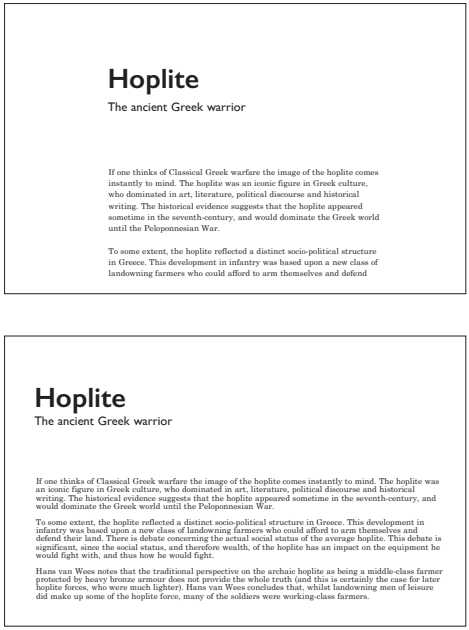

FIGURE 6.

Moderate line length and an additional interlinear space of 4 points [top]. Long line length and type set solid [bottom].

as 'leading', relating to the strips of lead of varying thickness that were placed between lines of type to increase the space.

As already highlighted, researchers, authors, and practitioners agree that line length must be coordinated with type size and interlinear space for any final judgement concerning the legibility of type (Tinker, 1963a, 73; Zachrisson, 1965, 39; Reynolds, 1978, 200; Rehe, 1979, 29; Carter *et al*, 1993, 91; Wijnholds, 1997). An inadequate ratio of type size to line length results in the text appearing unbalanced. For instance, when text is set fully justified, a badly chosen ratio can result in stretched words separated by large gaps (Wijnholds, 1997). These observations offer a clear suggestion that line length cannot be determined without considering type size. The same association has been made between line length and interlinear space. When it is really necessary to use long line lengths, legibility can be preserved if interlinear space is increased (Schriver, 1997, 263) in order to help the eye find the following line accurately.

Paterson and Tinker (described by Tinker, 1963a, 94-102) completed a series of experiments between 1932 and 1949, which varied line length (from 7 picas, about 18 characters, to 43 picas, about 124 characters) and interlinear space (from solid to an increase of 4 points) for each of the commonly used type sizes (from 6-to 12-point type). Speed of reading for material set in each of the variations in line length and interlinear space was compared for each size of type. This extensive and detailed investigation made it possible to list 'safety zones' for each type size. (See Tinker, 1963a, 106.) According to Tinker, the safety zone refers to the limits of variation in line length and interlinear space that may be used for a given type size without appreciable loss of legibility. On the basis of Tinker's (1963a) safety zones, it seems that for the sizes of type suggested above as the most legible (9-, 10-, 11-, and 12-point), one to four points can be added to the interlinear space in order to increase legibility. However, this surely depends on the typeface used. Extreme line lengths were omitted from the list. For example, for 10-point type, line lengths below 14 picas (about 38 characters) and above 31 picas (about 83 characters) were omitted. An examination of the results in Tinker's tables shows that, independent of the interlinear space used, those extreme line lengths always fell in the region of poor legibility.

Tinker (1963b) then carried out another experiment, which confirmed Paterson and Tinker's findings. Moderate arrangements (in this case of 8-point type with a line length of 12 picas – about 41 characters, or 9-point type with a line length of 18 picas – about 55

characters, both with an additional interlinear space of 2 points) were read more rapidly than text in relatively long or short lines, smaller type sizes, and with little or no interlinear space. Readers' choices were consistent with their performance and they definitely disliked text in relatively short or long lines, small type, as well as material set solid.

Becker *et al* (1970) also found that according to readers' judgements, different typefaces need a different amount of interlinear space. For instance, sans serif and italic may need an additional interlinear space of 1 point more than serif roman types. Schriver (1997, 263) also suggests that it is a good idea to insert more interlinear space between the lines of sans serif type because the uniform line weight and similarity of letterforms may make it harder to read the text smoothly.

Authors and practitioners (e.g. Simon, 1945; Tschichold, 1967; Spencer, 1969; Rehe, 1979; Black, 1990; Bringhurst, 1992; Carter *et al*, 1993; Schriver, 1997, Wijnholds, 1997) seem to agree with these findings and indeed go further by adding other considerations concerning interlinear space that should be taken into account when arranging text. For example, body text usually needs an interlinear space in a point size bigger than the size of the type. Even though the type is designed to maintain a legible appearance when set solid, the space between lines can still look insufficient. If so, the eyes take in other lines as well. However, too much interlinear space is also bad because when lines are too separated it will take longer to get to the following line (Tschichold, 1967, 44; Rehe, 1979, 31; Bringhurst, 1992, 34-5; Carter *et al*, 1993, 91; Schriver, 1997, 260-1). That is to say, it is more difficult for the eyes to make an accurate return sweep to the beginning of each new line of text (Simmonds and Reynolds, 1994, 35 and 52). Furthermore, it is also more expensive because of the additional paper used (Wijnholds, 1997). As discussed above, longer line lengths always need more interlinear space than shorter ones (Schriver, 1997, 262-3).

TABLE 6.

Type size, line length and interlinear space

Research	Practice
• For sizes of type 9-, 10-, 11-, and 12-point (suggested as the most legible) an interlinear space of one to four points can be added to increase legibility [Tinker, 1963a]	• Arrangements of 10- and 11- point size, with a line length of 60 to 70 characters per line, and additional interlinear space of one to four points, are considered most legible. [e.g. Simon, 1945; Tschichold, 1967; Hartley and Burnhill, 1977; Spencer, 1969; Black, 1990; Bringhurst, 1992; Carter *et al*, 1993; Schriver, 1997; Winjholds, 1997]
• Moderate arrangements are read more quickly than text in relatively long or short lines, smaller type sizes and with little or no interlinear space. [Tinker, 1963b]	• Italic, body text and sans serif type, may need an additional interlinear space of one point more than serif roman types. [Becker *et al*, 1970; Schriver, 1997]
• Readers definitely dislike very short and very long lines, small type, as well as material set solid. [Tinker, 1963b]	

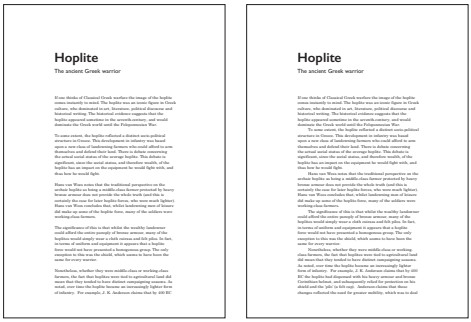

FIGURE 7.

Paragraphs denoted by one line space [left] or by a new line with a moderate indentation of 3 ems [right].

Paragraphs distinguish units of thoughts. The most common ways of showing the beginning of paragraphs are the introduction of an indentation, a line space, or a combination of both.

Paterson and Tinker (1940; described in Tinker, 1963a, 122) examined the effects of paragraph denotation on speed of reading. Results showed that indentation at the beginning of a paragraph improved, or at least did not decrease, the legibility of printed matter. Hartley *et al* (1978), with a later experiment, investigated the effects of paragraph denotation on legibility of text by measuring speed of scanning, i.e. the number of items scanned in a given period. For each setting the start of new paragraphs was denoted in one of four ways: [1] one line space but no indent; [2] a new line with indent; [3] a new line with no indent; [4] no denotation at all. Results clearly showed that paragraphs denoted by one line space but no indent were significantly superior to paragraphs denoted only by a new line with no indent, and also superior to those units of text with no denotation at all. However, paragraphs denoted by one line space but no indent were not significantly different from paragraphs denoted by a new line with indent.

Schriver (1997, 356-7) added to Tinker and Hartley's findings. For continuous text, thirteen participants preferred the double-signalled layout using both indentation and additional line space; three chose the layout with additional line space between paragraphs; and two favoured the layout that employed indented paragraphs without extra line space. The comments made by the thirteen readers who chose the same style suggested that they thought this style made the text appear easier and shorter than the others.

Authors and practitioners are in favour of denoting paragraphs in books, magazines and newspapers, with a moderate indentation of one to three ems (Rehe, 1979, 51; Bringhurst, 1992, 38; Carter *et al*, 1993, 93).

As for the first paragraph in an article, chapter or advertisement, it should have no indent (Simon, 1945, 9; Tschichold, 1967, 49; Carter *et al*, 1993, 93). This is a way of maintaining the square corner of the first column for aesthetic reasons. The use of paragraphs separated by one line space is also advocated (Hartley and Burnhill, 1977a, 71; Rehe, 1979, 51; Hartley, 1994, 35). However, Carter *et al* (1993, 93) suggest that this system should be avoided when the text is composed mainly of short paragraphs, not only because it creates a disturbing texture but also because it occupies too much space.

Simmonds and Reynolds (1994, 61) further point out that with scientific and technical information, one line space between

paragraphs makes it easier for readers to return to the paragraphs and find their points of interest.

TABLE 7.

Paragraphs

Research	Practice
• Paragraphs denoted by one line space (no indent) are significantly superior than paragraphs denoted only by a new line, but not superior than paragraphs denoted by a new line with an indent. [Hartley *et al*, 1978]	• In books, magazines and newspapers, paragraphs should be denoted with a moderate indentation of one to three ems, or separated by one line space. [Hartley and Burnhill, 1977a; Rehe, 1979; Bringhurst, 1992; Carter *et al*, 1993; Hartley, 1994]
• Readers favour paragraphs denoted by indentation and additional line space. [Schriver, 1997]	• The first paragraph in an article, chapter or advertisement, should have no indent. [Simon, 1945; Tschichold, 1967; Carter *et al*, 1993]
	• Paragraphs separated by one line space should be avoided when the text is composed mainly of short paragraphs. [Carter *et al*, 1993]

4.3.5. Margins

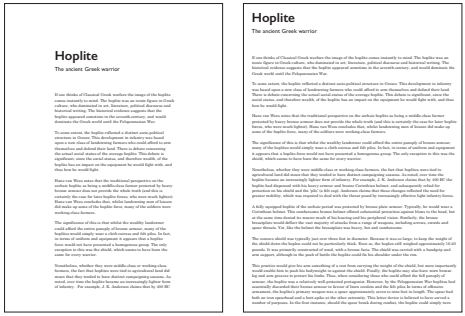

FIGURE 8.

Wide margins [left] and narrow margins [right].

Unfortunately, the amount of research with regard to margins is very limited. Of the very few studies on the effects of margins on legibility, a study by Paterson and Tinker (1940; summarised in Tinker, 1963a, 114) investigated the effects of margins on reading speed. Material with $^{7}/_{8}$ inch margins on the right and on the left of the column of print was compared with material without margins at either end of the lines. (It is likely that there was a very small margin, but no illustration is given to confirm this.) The results showed no significant speed difference when reading material printed on a flat page with or without margins. The final conclusion was that margins do not increase legibility measurably, so the use of margins on a flat page can be justified only for aesthetic reasons.

Spencer (1969, 48) criticised Paterson and Tinker's conclusion for ignoring practical factors. As Spencer stressed, margins have the important function of allowing the readers to make notes and hold the book without covering any part of the printed text or image. Hartley (2004, 918) also mentions the fact that the printed page may be copied at some time, and the copies punched or clipped for filing with

other material. These issues have been discussed by several authors and practitioners such as Simon (1945), Tschichold (1967), Bringhurst (1992), and Carter *et al* (1993). As McLean (1980, 126) further emphasises, the smaller the margins, the less they can fulfill these practical functions.

TABLE 8.

Margins

Research	Practice
• Margins do not seem to increase reading speed. [e.g. Paterson and Tinker, 1940 (described in Tinker, 1963a, and cited in Spencer, 1969)]	• Margins are functional as they allow the readers to: make notes; hold the book without covering any part of the printed text or image; punch or clip copies for filing without damaging the text. [e.g. Simon, 1945; Spencer, 1969; Tschichold, 1967; McLean, 1980; Bringhurst, 1992; Carter et *al*, 1993; Hartley, 2004]

4.4. CONFIGURATION

4.4.1. Headings

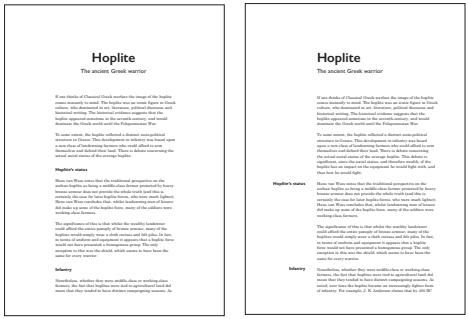

FIGURE 9.

Embedded headings [left] and marginal headings [right].

Headings are claimed to be a significant help for readers in decoding the main topic of the subsequent text they are planning to read (Schwarz and Flammer, 1981, 61 and 65; 1985; Lorch, 1989, 210), as well as the hierarchical structure of the text (Glynn *et al*, 1985, 197). Due to the importance of headings, it has been suggested that when discussing the treatment of headings three factors should be considered for good legibility: type size, type weight (Glynn *et al*, 1985, 197) and spatial location on the page (Lorch, 1989, 214). These are the most frequently used ways of emphasising and distinguishing headings from the main text or distinguishing between headings at different levels.

Type variation has been addressed by Williams and Spyridakis (1992)in a detailed study that looked at the visual distinction of headings in text. Participants were presented with 16 cards with the same meaningless text, but each one had different heading treatments. The results indicated that participants could discriminate between different hierarchical levels of headings more quickly when fewer typographical variations were used. Size (when used alone) was chosen by readers as the most powerful visual feature of a group of four (type size, underlining, case, and position) to distinguish the hierarchy of headings. The experiment showed that relative, not absolute, differences in heading sizes provided the most distinguishable cues to hierarchical level. Size differences of 3 points

between headings were discriminated more rapidly with headings ranging between 12 and 21 points in size than with headings in larger sizes.

In relation to the spatial location of headings, Hartley and Trueman (1983) conducted a series of experiments to examine the effects of headings in text on recall, search, and retrieval. The results revealed no difference in accuracy between marginal and embedded headings for recall, search, or retrieval. Williams and Spyridakis (1992), however, showed that participants consistently judged centred headings as most important and embedded headings as least important. Left aligned and indented headings were ranked second and third in importance.

Some considerations to take into account when setting text headings have been pointed out by the typographer Tschichold (1967):

- When the heading spans over more than one line, the first line of the heading must be either longer or shorter than the second one. If necessary, interword space can be slightly changed, but word breaks should be avoided (1967, 44).
- When the text is set in sans serif type, only sans serif type should be used for headings, either in the same weight or bolder. With serif text, either the same type may be used for headings, or the semi-bold or bold, or a suitably and pleasing contrast type (1967, 89).
- Normal paragraph headings, if set heavier than the body face, do not need to be in a larger size. A blank line is preferable between them and the text (1967, 89).

Simmonds and Reynolds (1994, 67) add to this the recommendation that headings should be aligned left because the eye automatically returns to the left-hand margin of the text. Moreover, a heading with more space around it has more emphasis, but it is important to define a system of spacing for headings and use it consistently.

Hartley (2004, 921) also suggests that the use of all-capitals for main headings, or small capitals for secondary headings, may be satisfactory because such headings are normally surrounded by space, which helps in their perception (as already remarked above regarding capitals versus lowercase). He also regards large sizes of 14-, 18-and 24-points as suitable for headings (Hartley, 2004, 919).

There has also been research on newspaper headlines. In terms of the typeface, scientific evidence reveals that headlines in newspapers are more difficult to locate (measured by speed of search) when printed in all-capitals (whose height is about the same as the x-height of the lowercase letters) than when printed in bold lowercase letters (Poulton, 1967, 424). In his review, Rehe (1979, 52) recommends the best type sizes for newspaper headlines as between 14-and 30-point.

Wright and Barnard (1975) warn that, although there are several options for distinguishing headings from the subsequent

text, departures from the horizontal arrangement of words are less easily read. This means, "a heading printed sideways, to bracket several rows of questions all relating to the same topic, will be less effective than a heading written horizontally." (Wright and Barnard, 1975, 216).

TABLE 9.

Headings

Research	Practice
• Relative differences in sizes provide the best cue to distinguish the hierarchy of headings. [Williams and Spyridakis, 1992]	• When serif type is used for the main text, set the heading in semi-bold or bold, or in a suitable and pleasing contrast type. [Tschichold, 1967]
• Readers consider size (when used alone) to be the most powerful visual feature to distinguish headings. [Williams and Spyridakis, 1992]	• When sans serif type is used for the main text, only sans serif type should be used for headings, either in the same weight or bolder. [Tschichold, 1967]
• No difference in accuracy between marginal and embedded headings. [Hartley and Trueman, 1983]	• Normal paragraph headings, if set heavier than the body type, do not need to be in a larger size. A blank line is preferable between them and the text. [Tschichold, 1967]
• Centred headings are judged as most important, then left aligned and indented headings, and embedded headings as least important. [Williams and Spyridakis, 1992]	• The first line of the heading must be either longer or shorter than the second one (word breaks should be avoided). [Tschichold, 1967]
	• Headings should be aligned left. [Simmonds and Reynolds, 1994]

4.4.2. Columns

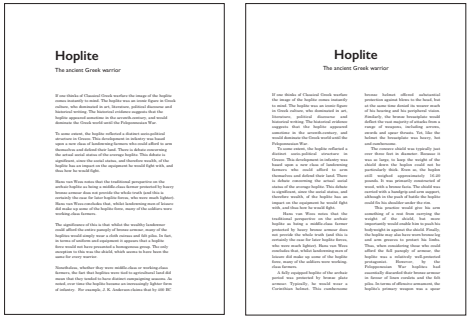

FIGURE 10.

Single column [left] and double columns [right].

Little attention appears to have been paid to how text is set in columns. However, the evidence available on single or multiple columns suggests that neither of these layouts is superior to the other. In fact, it seems that any advantage in terms of legibility, i.e. speed of reading, for either of these layouts largely depends on the column width, on the nature of the text, and on the circumstances of use.

In situations where participants are required to scan the text and search for key words, the double column layout seems to have an

advantage over the single column layout. An example of this is the study carried out by Foster (1970) on the legibility of single and double column layouts. Participants had to scan a one-column text and a two-columns text for target words. Page size, typeface and type size used were identical in both texts. Foster (1970) concluded that for this particular arrangement, the single column layout significantly diminished legibility, i.e. the number of target words located.

Hartley *et al* (1978) used texts arranged in either single or double column to test the effects of line length and paragraph denotation on the retrieval of information from prose text. Performance was measured by the number of items scanned. Again, results were in favour of the double column layout in terms of the average number of items scanned. It is concluded that the double column layout is probably preferred to a single column for the setting of straightforward prose, at least in terms of cost-effectiveness, as it is possible to get more words in the page.

In relation to textbooks for secondary schools, in Wendt's (1979) study, participants were asked to read the texts completely and carefully. They took, on average, a little less reading time and had slightly higher achievement with the single column version compared to the double column version. However, these results were not significant. The students slightly preferred the double column version, though.

A similar preference was reported in a study conducted by Paterson and Tinker (1940; cited in Tinker, 1963a, 117-8), where samples of single and double column layouts were submitted for preference. It was reported that a large percentage of participants preferred the double column layout over the single column layout. But preferences may have been influenced by the fact that a double column is more familiar, since printing practice has favoured double column layouts.

For scientific journals, Poulton (1959) reported an advantage in favour of single columns, which were read more rapidly than the double column. Passages were printed in a layout of a scientific paper (but without title, subheadings, summary, tables, etc.). However, the two single column layouts had a larger serif type and a longer line length. Therefore, it is possible that the significant advantage of the single column layout over the double column layout in terms of speed of reading and comprehension might have also been related to the change in type size, and not just to the number of columns.

For reading examination materials using academic texts from scientific journals and magazines, Lonsdale *et al* (2006) and Lonsdale (2007) reported an advantage in favour of the single column layout. Participants took less time to read and answer questions with the single column layout. The number of correct answers was also higher with this layout. In terms of judgement, participants also considered that the answers were easier to locate with the single column layout. However, as in Poulton's (1959) study, other typographic features were manipulated. Both layouts

had the same Time News Roman typeface and the same type size of 10.5 points. Logically, as the page size was the same, the single column layout had a longer line length (70 characters) than the double column layout (42 characters). In addition, the single column layout had an interlinear space of 14 points (as opposed to 11 points), and the paragraphs were distinguished by a line space (as opposed to an indent of 35mm at the beginning of the paragraphs with no line space). Therefore, the advantage of the single column layout over the double column layout seems to be related to a combination of typographic features that work together in order to produce a more legible layout.

Authors have also made some recommendations concerning the structural nature of the text, page size, margin width, as well as circumstances of use. It has been proposed that for straightforward prose to be set on an A4 page, a double column arrangement with a medium line length is probably better than a single column arrangement with long lines (Rehe, 1979, 50), unless wide margins are used with the single column (Simmonds and Reynolds, 1994, 54). Moreover, if the text requires headings or integrates non-textual elements that could occupy the space of two columns (e.g. large tables, diagrams, or figures), then a single column layout is advisable (e.g. Hartley and Burnhill, 1977a, 69; Southall, 1984, 87). However, if the non-textual elements have different sizes, two columns give more flexibility (Simmonds and Reynolds, 1994, 54). If the two columns are asymmetric, for example, a wider column and a narrow column, even more flexibility is possible. As explained by Simmonds and Reynolds (1994, 54), with a wider and a narrower column the non-textual elements can occupy the wider column, the narrower column, or both. According to the authors, the narrower column can also be used for headings, captions, and notes, as well as small illustrations. However, Simmonds and Reynolds emphasise the importance of avoiding having too many different elements competing for attention in the narrower column.

In conclusion, decisions regarding columns cannot be taken by considering line length alone. Instead, all the structural requirements of the text and circumstances of use have to be taken into account (Hartley *et al,* 1978, 193-4). Carter *et al* (1993, 91) add that, as column measure increases, the interlinear space should also increase to maintain a proper ratio of column width to interlinear space (as discussed above).

TABLE 10.

Columns

Research

- When scanning for target words, the double column layout seems to have an advantage.
  [Foster, 1970; Hartley *et al*, 1978]
- For scientific journals and exams, a single column layout is read quicker.
  [Poulton, 1959; Lonsdale *et al*, 2006; Lonsdale, 2007]

Practice

- For straightforward prose a double column layout with a medium line length is better than a single column layout with long lines. Unless wide margins are used with the single column.
  [Rehe, 1979; Simmonds and Reynolds, 1994]
- If the text requires headings or integrates non-textual elements that could occupy the space of two columns, a single column layout is advisable.
  [Hartley and Burnhill, 1977a; Southall, 1984]
- If the two columns are asymmetric the narrower column can be used for headings, captions, and notes, as well as small illustrations
  [Simmonds and Reynolds, 1994]
- As column measure increases, the interlinear space should also increase.
  [Carter *et al*, 1993]

FIGURE 11. BELOW

Layouts intended to be: more legibile [top left], of medium legibility [top right], less legible [bottom left] – based on Lonsdale et al's study (2006).

5. TYPOGRAPHIC STRUCTURE

5.1. TEXT STRUCTURE

Jonassen (1985, 187) notes that text structure should be clear to readers, as it can give clues about the location of information in the text. Hartley and Burnhill (1976, 100) also argue that a clear structure of text is important, as readers cannot focus on the content if at the same time they have to sort out the arrangement of the material (see also Hartley, 1980a, 1980b, 1994, 2004; and Hartley and Burnhill, 1977b). With this view as a basis, some experimental comparisons have been conducted to assess legibility of original versus revised layouts, using speed of reading and accuracy as measures. Hartley and Burnhill (1976), for example, revised and compared a printed document circulated by the British Psychological Society (BPS) with the original version. The revision consisted of manipulating a combination of typographic features, mainly the rational use of vertical (additional space between line and sections) and horizontal space (wider margins and inclusion

of some marginal headings) to clarify the hierarchical structure of the document. Participants were asked to find and circle information in one or other of the two documents. The results demonstrated that participants with the original document took longer to find the main items on the page, and a considerable percentage (50 per cent) did not find any item at all. Hartley and Burnhill's (1976) concluding comment was that function and form must work in parallel, and if writers, editors, and printers think more about the spatial arrangement of text, then the way the content is logically structured will be improved.

Two other studies (Lonsdale *et al*, 2006 and Lonsdale, 2007), already mentioned in the previous section, tested the effect of text layout on performance in the particular context of examination-type situations. The three layouts tested were chosen from existing examinations and were intended to represent three levels of legibility: layout 1 was intended to be more legible than the other two; layout 2 was intended to have medium legibility, and layout 3 was intended to be the least legible of the three. Results showed that layout 1, the one conforming to legibility guidelines (serif type for the text, sans serif type for the headings, type size of 10.5 points, interlinear space of 14 points, line length of 70 characters, text left aligned, single column, wide margins and paragraphs distinguished by one line space with no indent) resulted in a shorter task time, better accuracy, and more correct answers per second. This layout was also perceived as making it easier to locate answers.

Preferences for different typographic layouts have been further examined. Hartley and Trueman (1981) developed an experimental comparison to see the contributions that changes in layout could

TABLE 11.

Text structure

Research	Practice
• The rational use of horizontal and vertical space clarifies the hierarchical structure of the document. Readers favour these structures. [Hartley and Burnhill, 1976; Hartley and Trueman, 1981]	• Text structure should be clear and give clues about the location of information in the text. [Jonassen,1985; Hartley and Burnhill, 1976; Hartley, 1980a, 1980b, 1994 and 2004; Hartley and Burnhill, 1977b]
• Layouts conforming to legibility guidelines (serif type for the text, sans serif type for the headings, type size between 10- and 11-points, interlinear space of 14 points, line length of 70 characters, left aligned text, single column, wide margins), result in better performace and are perceived as easier to read. [Lonsdale *et al*, 2006; Lonsdale, 2007]	

make to the effectiveness of a particular text. A large number of students were asked for their preferences for text versions that varied in terms of their layout (features such as typeface, space, and configuration). Results showed a significantly greater preference for the layout in which the typographic features had been manipulated in order to increase the effectiveness of a particular text.

In all these experiments, great importance was given to the manipulation of space as a simple way to help readers see clearly the structure of the printed information when looking at the whole page.

6. SUMMARY AND RATING OF STUDIES

All of the studies mentioned in this paper are listed in Table 12 to give further information on the different approaches followed by each researcher, as well as the results obtained. The studies have been rated taking into account sensitivity and detail, i.e. whether

_ more than one measure was used,
_ there was an adequate check of accuracy when testing only reading speed,
_ there was a sufficient number of participants,
_ the reading materials tested were real-life materials, as opposed to unrealistic simulations,
_ the reading materials had the same level of difficulty,
_ an example/illustration of the reading materials was presented,
_ the reading task tested was a task performed in real-life reading situations,
_ the reading materials were long enough to produce reliable results,
_ the x-height was considered when testing different fonts,
_ different typographic variables were considered in relation to each other.

After reviewing the literature, it seems that speed of reading continuous text is one of the most satisfactory methods available for investigating typographic legibility and, therefore, the most widely used. Preferences are not as sensitive as speed of reading and users' judgements do not always agree with their performance. For these reasons, studies testing only preferences do not score high on the table. It should be also noted that secondary sources (indicated with SS on the table) are not rated because there is not sufficient information to make a fair judgment.

TABLE 12.

	RESEARCHERS	MEASURE	SUBJECTS	MATERIAL	FINDING	RATING
Typeface	Pyke (1926)	Reading speed Accuracy Preferences	–	48 lines of text per page	NS	SS
	Paterson and Tinker (1932)	Reading speed w/ accuracy check	900 (10gp X 90)	30 paragraphs of 30 words each	NS	***
	Burt (1959)	Reading speed Accuracy Preferences	–	One page long passage	NS	SS
	Tinker (1963a)	Preferences	210	–	S	SS
Serif vs sans serif	Poulton (1965)	Reading speed w/ accuracy check	375 (6 groups)	450 words long passages	NS	****
	Moriarty and Scheiner (1984)	Reading speed	260	Sales brochure	NS	***
	Schriver (1997)	Preferences	67	Documents typically used	NS	***
Italic	Tinker and Paterson (1928)	Reading speed w/ accuracy check	320 (4gp X 80)	30 paragraphs of 30 words each	S	***
	Paterson and Tinker (1940; described in Tinker 1963a)	Preferences	224	–	S	SS
	Tinker (1955)	Reading speed w/ accuracy check	192 (6gp X 32)	450 items of 30 words each	S	***
Bold	Luckiesh and Moss (1940)	Reading speed Rate of blinking	40	Continuous text	NS NS	***
	Tinker and Paterson (1942)	Reading speed w/ accuracy check Preferences	100 224	5 paragraphs of 30 words each	NS S	***
All-capitals vs lowercase	Tinker and Paterson (1928)	Reading speed w/ accuracy check	320 (4gp X 80)	30 paragraphs of 30 words each	S	***
	Tinker and Paterson (1942)	Reading speed w/ accuracy check Preferences	320 224	5 paragraphs of 30 words each	S S	***
	Tinker (1955)	Reading speed w/ accuracy check	254 (2gp X 127)	450 items of 30 words each	S	***
	Poulton (1967)	Searching speed w/ accuracy check	264	Newspaper (2 sheets)	S	*****
Type size	Paterson and Tinker (1929)	Reading speed w/ accuracy check	320 (4gp X 80)	30 sentences of 30 words each	S	**
	Tinker (1963a)	Preferences	224	–	S	SS
	Poulton (1972)	Searching speed w/ accuracy check	262	List of food ingredients	S	****

	RESEARCHERS	MEASURE	SUBJECTS	MATERIAL	FINDING	RATING
Colour	Tinker and Paterson (1931)	Reading speed w/ accuracy check	850 (10gp X 85)	30 paragraphs of 30 words each	S	***
	Luckiesh and Moss (1938, described in Tinker 1963a)	Reading Speed Rate of blinking Preferences	20	Continuous text	NS S	SS
	Michael and Jones (1955)	Accuracy	688 (4 groups)	Examinations	NS	***
	Tinker (1963a)	Preferences	210	30 paragraphs of 30 words each	S	SS
Interletter/ interword spacing	Spencer and Shaw (1971)	Reading speed Accuracy Searching speed	100 (5 groups)	500 words long texts	NS	*****
Alignment	Zachrisson (1965)	Reading speed (eye-movements)	48	20 lines of text	NS	**
	Fabrizio et al (1967)	Accuracy speed and level Reading speed (eye-movements)	216 18	Davis Reading Test = 4 test forms with 80 items each	NS	***
	Becker et al (1970)	Preferences	80	6 pages long text	NS	**
	Gregory & Poulton (1970)	Reading speed Accuracy	72	450 words passages	NS	*****
	Hartley and Burnhill (1971)	Reading speed Accuracy Preferences	49	2500 words long passages	NS	*****
	Hartley and Mills (1973)	Reading speed Accuracy Preferences	156 (2 groups) 61	700 words long passages	NS NS	*****
	Wiggins (1977)	Reading speed w/ accuracy check	324	30 paragraphs of 30 words each	NS	***
Line length	Wiggins (1977)	Reading speed w/ accuracy check	300	30 paragraphs of 30 words each	S	***
Interlinear space Type size Line length	Paterson and Tinker (1932 to 1949; described in Tinker 1963a)	Reading speed w/ accuracy check	11420	30 paragraphs of 30 words each	S	SS
	Tinker (1963b)	Reading speed w/ accuracy check Preferences	820 (10gp X 82) 180	30 paragraphs of 30 words each	S S	****
Paragraphs	Paterson and Tinker (1940; described in Tinker 1963a)	Reading speed w/ accuracy check	180	6 paragraphs with 15 words each	S	SS
	Hartley et al (1978)	Scanning speed w/ accuracy check	500 (8 groups)	4 pages long text	S	****
	Schriver (1997)	Preferences	18	2 page spreads	S	**

TABLE 12. *CONTINUED*

	RESEARCHERS	MEASURE	SUBJECTS	MATERIAL	FINDING	RATING
Margins	Paterson and Tinker (1940; described in Tinker 1963a)	Reading speed w/ accuracy check	190	30 paragraphs of 30 words each	NS	SS
Headings	Poulton (1967)	Searching speed w/ accuracy check	264	Newspaper (2 sheets)	S	*****
	Hartley and Trueman (1983)	Recall + Search + Retrieval (all w/ accuracy check)	1270 (9 groups)	3 1/2 pages long passages	NS	****
	Williams and Spyridakis (1992)	Discriminability Preferences	30	16 cards with meaningless text	S S	****
Columns	Paterson and Tinker (1940; described in Tinker 1963a)	Preferences	241	Article	S	SS
	Poulton (1959)	Reading speed w/ accuracy check	275	2 passages of 1,150 words	S	****
	Foster (1970)	Reading speed w/ accuracy check	40	One page article	S	***
	Hartley et al (1978)	Scanning speed w/ accuracy check	500 (8 groups)	4 pages long text	S	****
	Wendt (1979)	Reading speed Achievement Preferences	600 (4gp X 150)	2 page spread – textbook	NS –	*****
	Lonsdale (2006)	Reading speed Accuracy Efficiency Preferences	30	Passages of 800 words	S S	*****
	Lonsdale (2007)	Reading speed Accuracy Efficiency Preferences	90 (3gp X 30)	Passages of 800 words	S S	*****
Text structure	Hartley and Burnhill (1976)	Reading speed w/ accuracy check	20	Pamphlet pages of 300 words	S	****
	Hartley and Trueman (1981)	Preferences	315 (5 studies)	Pages of instructional text	S	***
	Lonsdale (2006)	Reading speed Accuracy Efficiency Preferences	30	Passages of 800 words	S S	*****
	Lonsdale (2007)	Reading speed Accuracy Efficiency Preferences	90 (3gp X 30)	Passages of 800 words	S S	*****

7. CONCLUSION

This literature review started by discussing evidence on how each typographic feature may affect legibility, i.e. the speed and accuracy of reading text. Legibility can be affected by the way features are treated that reside in the characters themselves, the horizontal and vertical space between characters or sets of characters, and the configuration of the text. However, it was clear throughout this individual analysis that, for good legibility, the various typographic features should be selected in relation to each other (as highlighted before by, for example, Lupton, 2004; Lonsdale *et al*, 2006; Lonsdale, 2007). Each typographic choice affects the other. For example, it does not seem sufficient to have text set in a moderate line length if at the same time a small type size with little or no interlinear space are used and paragraphs are not sufficiently distinguished. Therefore, the various features that define a typographic layout should be combined and manipulated as a group to make the layout legible.

Equally important is the fact that the present literature review took two fundamental and distinct approaches into account, i.e. legibility research and typographic practice. Although legibility research and typographic practice do not always reach the same conclusions, both contribute to the study of the typographic features of text. Typographic practice can usefully inform legibility research on which material is relevant to test, whilst legibility research can give us clear information regarding readers' performance, tolerance, and preferences.

To give a concrete example, the mutual relationship between research and practice is of most importance in those particular cases where 1) the reader has no power to decline reading a text that he/she does not find legible and 2) reading a text has a direct link on performance and achievement. This is certainly the case in examinations (as supported by Lonsdale *et al*, 2006 and Lonsdale's, 2007 studies – Section 5) which are used extensively every academic year and for every subject field. But, interestingly enough, it is also the case for essays that are submitted by the students for assessment. This is supported by Hartley's *et al*' (2006) study conducted to test the effects of typographic variables on essay grades. The results showed that essays using a combination of popular and more legible typographic features gained significantly higher marks than those using other combinations.

Just in these two particular cases, the combined effort between research and practice would benefit teaching and learning by designing well informed solutions, as well as making available clear guidance on how typographic features of text can be used to minimise unwanted effects on performance and consequently on students' grades.

This is true for examinations and essays but would also be true for many other graphic materials similar to examinations and essays that are used everyday to teach, learn, study (e.g. classroom material,

textbooks, virtual learning environments), to research (e.g. journals, primary sources, academic books), to write about one's work (e.g. dissertations, projects, reports, presentation material), to read for general information (e.g. newspapers, magazines, websites, apps), to read for pleasure (e.g. magazines, books), to advertise (e.g. direct mail, brochures), and so on.

This review is therefore valuable in providing guidance on the design and preparation of typographic materials. It will help designers, researchers, scholars, as well as students and anyone using typography to make informed and educated typographic choices. If the aim is to communicate objectively and to facilitate ease of reading, then typographic legibility is the answer.

ACKNOWLEDGMENTS

The author would like to thank Mary Dyson and Linda Reynolds from the Department of Typography and Graphic Communication at the University of Reading, who contributed to her research with their suggestions, knowledge and advice. The author also wishes to express her sincere gratitude to Mike Zender and the anonymous reviewers whose valuable comments helped strengthen this paper.

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ABOUT THE AUTHOR

Maria dos Santos Lonsdale is a lecturer, researcher and graphic designer. She is Currently teaching at the University of Hull, Cottingham Road, HU6 7RX, UK. Having taught Graphic Design and Psychology of Perception in Portugal, she came to do a Ph.D at the Department of Typography and Graphic Communication, University of Reading, UK. Her research involves Typographic and Graphic Design, Psychology of Reading, and various research methods including experimental studies. Her research interests lie in typographic design of instructional and information materials and how they affect performance.

Book Review:

Design for information, an introduction to the histories, theories, and best practices behind effective information visualizations.

by

Isabel Meirelles

Beverly, MA: Rockport Publishers, 2013.

Jorge Frascara

Design for information is a thorough representation of both the field of information visualization and the research interests of the author, whose focus is on "the theoretical and experimental examination of the fundamentals underlying how information is structured, represented and communicated in different media."

Beginning with the "big picture," the book includes an amazing collection of examples, the most thorough I have seen to date in a volume. The author organizes the content according to several categories represented by the titles of the chapters: 1. Hierarchical structures: trees; 2. Relational structures: networks; 3. Temporal structures: timelines and flows; 4. Spatial structures: maps; 5. Spatio-temporal structures; and 6) Textual structures. An appendix, notes, a bibliography, a contributors list, and an index complete the content of the book.

Design for information is an extensive taxonomy of data visualization types and is "a must" for anybody interested in the work done in the area. Each one of the hundreds of examples is explained and discussed, forming a kind of encyclopedia on the subject. It seems that nothing escaped the exemplary collection that Meirelles assembled. The discussions and explanations normally focus on what information is represented and how it is represented.

It is interesting to see, as well, how many different professional fields today use diagrams to organize and represent information: basic science, applied science, education, engineering, medicine, and technologies, etc. The value of the book is centered on the inclusion of examples of how many different problems are now being addressed through data visualizations, how many historical efforts preceded whatsoever is

done today, and how the advent of the computers have allowed the field to explode by handling large data sets as well as dynamic representations.

At the end of the examination of the 224-page volume I became curious as to how these diagrams might have performed with the users they were intended for in terms of ease of comprehension; what conclusions I could arrive at from an evaluation of the examples from a perceptual and cognitive human factors perspective; or how a complementary book could contribute to the development of best practices. I would not expect that one volume could be so extensive as this one and also cover the field critically. However, I have to wonder how the super-complex visualizations permitted by computer programs today would perform regarding comprehension, memorization, and use of the information presented. The discussion on perception and cognition is very brief, and it might leave some readers wondering about the assertions made: they are proposed as principles without them being discussed. This topic, as well as Gestalt theory, are not considered during the description of examples. The size of some reproductions is too small to assess their quality as data visualizations. They appear as examples of problems addressed but not as information in themselves. To compensate for this, the book includes valuable URLs for people interested in seeing in better detail many of the diagrams shown.

While the above issues could be perceived as weaknesses, the strength of the book is its truly amazing array of examples and the rare historical diagrams it offers. It also displays an uncommon erudition and includes an extensive and useful bibliography. I do not know how long Meirelles took to complete the manuscript, but it feels like a lifetime project. These assets, coupled by excellent production, make this an indispensable publication for anyone interested in information visualization.

Book Review:

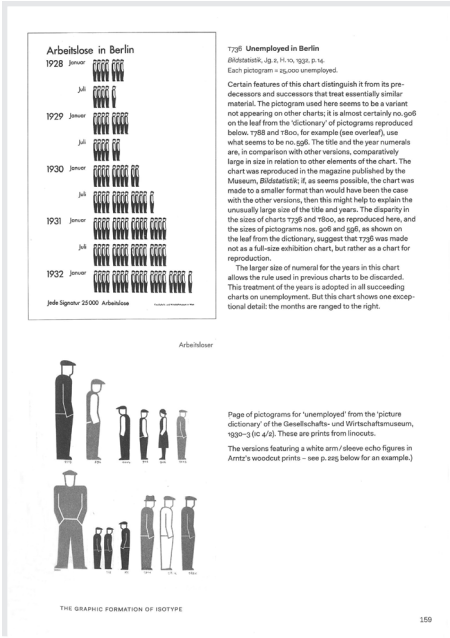
Isotype: Design and contexts 1925–1971

by

Burke, Christoher; Kindel, Eric; Walker, Sue (Eds.)

Hyphen Press, London, 2013

Per Molleup



Page 158
Males with flat cap and hands in pocket stereotype unemployed persons. Striking workers have crossed arms.

Isotype, why not?

The term Isotype, an acronym for International System Of TYpographic Picture Education, is a technique of data visualization introduced by sociologist, economist, and philosopher Otto Neurath. Originally called "The Vienna School of Pictorial Statistics" and developed and practiced at the Gesellschafts- und Wirtschaftsmuseum in Wien (Social and Economic Museum of Vienna), 1925-34, Isotype's purpose was to communicate societal information to visitors. In 1935, Neurath's technique was renamed, and Isotype began its own life and was used for other purposes in other places.

Isotype builds on the idea expressed in Neurath's often-repeated adage, "To remember simplified pictures is better than to forget accurate numbers" (p. 85). Therefore, Isotype is best known for Picture tables—graphic displays with rows of repeated pictograms each standing for a number of real world units. The picture tables embody the proposition that it is easier to compare quantities by comparing numbers of well-presented symbols, than to compare symbols of different size. Pictograms in the Isotype picture tables are scaled: in a display showing unemployment, each pictogram would stand for 1,000; 100,000; or 1 million – or another round number of unemployed persons. In picture tables, the reader must count the pictograms in different groups and multiply with the scaling factor to get the total amounts. The number of the repeated pictograms in a picture table is most often rounded off. Some Isotype picture tables feature half, quarter, or smaller fractions of pictograms. Even then, Isotype displays are typically not as precise as the numbers they represent.

Isotype: Design and contexts 1925-1971 describes Isotype in a period delimited by 1925 when the Gesellschafts-und Wirtschaftsmuseum in Wien was founded and 1971 when the Isotype Institute in London closed. The book comprises 12 chapters dealing with the genesis and further development and design of Isotype. The book includes two kinds of information; it describes Isotype design principles, and it describes the process by which Isotype was developed and disseminated. To this reviewer the former part is the most interesting, while the latter part serves as a useful historical backdrop.

TEACHING MUSEUM

In the first of two central chapters, Christopher Burke covers the ten-year lifetime of The Gesellschafts-und Wirtschaftsmuseum in Wien including the formative years of Isotype. The idea behind Isotype predated the museum. Otto Neurath, sociologist, economist, and philosopher, had already applied charts with pictorial descriptions of quantities for the Museum für Siedlung und Städtebau, Museum for Settlement and Town Planning. Eager to educate by means of these didactic tools, Otto Neurath suggested a new museum to expand the ordinary population's understanding of national and world relations. The social democrat regime in Vienna understood the importance of education and provided the necessary financial support.

Otto Neurath invented Isotype, but more than that, he promoted it. Philosophically and organisationally trained in addition to being well connected academically and politically he spread the word and established the connections that were vital to the incubation of a new idea like Isotype. Neurath partnered his strong interest in education of ordinary people with his equally strong social commitment resulting in his belief that progress depends on knowledge, and knowledge should be delivered in ways that are both attractive and memorable – essential qualities of Isotype.

The Gesellschafts und Wirtshaftsmuseum in Wien was not a museum in the traditional sense of that word; and therefore consistent with Neurath's view that "The modern museum should be a teaching museum, a means of education, a schoolbook on a grand scale…" (p. 30). The Gesellschafts and Wirtshaftsmuseum in Wien consisted primarily of graphic charts explaining societal matters, first and foremost quantities. The museum introduced a number of advanced ideas to meet its audience. To accommodate prospective visitors the museum was open evenings and Sunday mornings. Also, the museum branched out at several places where visitors would be. At a certain time, the museum would exhibit at several different locations in Vienna including the town hall. A central corner shop museum open in the lunch hours had as many as two thousand visitors a day. At the corner shop special interactive knowledge machines were placed where visitors could test their knowledge – anticipating a distant, digital future. Exhibition material was reused and exchanged between permanent

and time limited exhibitions in several places. Along with its own exhibitions, the museum took part in fairs and exhibitions in Austria and abroad.

The museum also published books, pamphlets, and journals to reach its audience in time and space. *Gesellschaft und Wirtschaft*, Society and Economy, was a collection of 100 Isotype charts. *Fernunterricht*, distant teaching/learning, later renamed *Bildstatistik*, Pictorial Statistics, prefigured modern distance learning.

Three persons led the development of Isotype: Otto Neurath, a sociologist, economist, and philosopher; Marie Reidemeister, a German academic; Georg Arntz, a German graphic designer.

Austrian Otto Neurath's past career included his initiative to, and directorship of, the German museum of war economy in Leipzig during WWI. After the war, his presidency of the Central Office of Economics, in the Bavarian Soviet Republic, was followed by a conviction of assisting high treason and an eighteen-month, later suspended, prison sentence. In 1920, Neurath was back in Vienna to become the director of the Forschungsinstitut für Gemeindewirtschaft, Research Institute for Co-operative Economy. In this capacity Neurath initiated a Museum for Settlement and Town Planning, which within a year – also on Neuraths initiative – was replaced by The Gesellschafts-und Wirtschaftsmuseum in Wien.

Marie Reidemeister (after 1940 Marie Neurath) met Otto Neurath before the start of the Gesellschafts- und Wirtschafts Museum in Wien, became his right hand, and continued working with Isotype after Otto Neurath's death in 1945. Most importantly, Marie Reidemeister played and developed the role of 'transformer'. Otto Neurath and Marie Reidemeister considered the 'transformation' of a message into a principle for a graphic chart the crucial part of the work with Isotype. Transformation was the link between science and graphic design. According to Marie Reidemeister: "We think out which is the point that has to be brought home, and then we try to do so in such a way that everybody will grasp it. We avoid distracting the attention from the more important issues." (p. 15). Also according to Marie Reidemeister, other designers impressed by Isotype would emulate the form but hardly master the transformation (p. 14). Today, the term 'transforming' is not used, but the substance is a natural part of the work of information designers engaged in data visualisation in news media and elsewhere.

Georg Arntz was a German artist working with woodcuts in precise graphic shapes, which caught the attention of Otto Neurath. Georg Arntz began working for the museum in 1928 and in 1929 moved to Vienna where he developed the schematic graphic form that became a signature quality of Isotype. In the process he also changed the technical production from paper cuts to printing from linocuts.

Three conditions for launching Isotype were present. First, a strong-minded initiator with a firm social and educational commitment who was well connected politically; second, highly qualified principal collaborators; and third, a friendly political market.

Partly inspired by the political winds and the following possible need for a foothold outside Austria, Otto Neurath established in 1932 the affiliate Mundaneum to take care of international relations. In 1932 and 1933, Mundaneum established branches in Amsterdam and London respectively. In 1934, the International Foundation for the Promotion of the Vienna Method of Visual Education was established in The Hague. Later in 1934, when the political situation in Austria and Vienna as envisioned by Neurath became dangerous, he, his wife Marie Reidemeister, Georg Arntz, and two other collaborators moved to the Netherlands. The Gesellshafts- und Wirtschaftsmuseum was closed. Part of its material was already transferred to Mundaneum. The rest was seized by the new regime, not the first time a design initiative has been subject to political change. In 1940 the Neuraths moved on to England.

THE NETHERLANDS

Two chapters of the book deal with the continuous work in the Netherlands and England. In Vienna, Isotype had been a means to inform the visitors of the Gesellschafts- und Wirtschaftsmuseum. In the Netherlands the Neurath team had to earn their way from projects. Otto Neurath wrote two books in Basic English: *International Picture Language* and *Basic by Isotype*. Other jobs included production of a children's theatre puppet show and an art exhibition, *Rondon Rembrant*. Also, commissions resulted from Otto Neurath's frequent travels to the USA.

ENGLAND

When Germany occupied the Netherlands the Neuraths moved on to England, where Otto Neurath had been promised a teaching position at Oxford. The Isotype Institute was then established in 1942. The Isotype work in England followed two lines. The Neuraths wrote and designed a number of books for Adprint, a book packager who also published, and they worked on informative films together with British film producer John Rotha. The books dealt with the war effort and social policy. Apart from a couple of booklets this work included a three book series: *America and Britain*, *The Soviets and ourselves*, and *New Democracy*. Two chapters in *Isotype: Design and contexts 1925-1971* deal with film work and children's books respectively.

FILM

Documentary filmmaker John Rotha approached the Neuraths soon after their arrival in England to initiate a collaboration concerning films for the Ministry of Information. The first film, *A few ounces a day* about saving waste to be used in the war effort, was based exclusively on animated Isotype graphics. The Neuraths acted as de facto directors and Maria Neurath made a complete storyboard as well as the graphics to be animated. Later followed several films, where Isotype animations were combined with live action. A series of films that had significant results included, *Worker and*

warfront, which was shown for workers in factory canteens, *World of Plenty* and *Land of promise* which dealt with food and with planning respectively.

In 1945 Rotha established a special company, Unifilm, with himself and Otto Neurath as directors. After Otto Neurath's death Marie Neurath would continue the cooperation with John Rotha until 1948, when Unifilm closed down. In 1954 Marie Neurath contributed to a TV series, *The World is ours*, and in 1965 to a film *The physics and chemistry of water*.

The film work was not without problems. Some critics found that serious matters should not be treated through the genre of animation. The Neuraths complained when they did not have full control of the work, and Paul Rotha did not always find the necessary support for Isotype work from the Ministry. Professional designers recognise these kinds of problems. Otto Neurath also had some didactic reservations. Isotype on paper lets the viewer see and compare several displays concurrently in space, while film – working in time – doesn't provide that possibility. Also paper media, in contrast to film, gives viewers as much time as they want. Today video technology has solved this problem.

CHILDREN'S BOOKS

In her chapter about children's books Sue Walker rightly states that "The children's books produced by the Isotype Institute provide an excellent insight into Marie Neurath's work as a transformer and show that she had a particular skill in making charts and illustrations that were accessible to children of all ages." (p. 391). This chapter reaches beyond children's books: The account of Marie Neurath's approach is relevant to all designers concerned with data visualisation.

The children's book production took place from the 1940s into the 1970s. Otto Neurath took the initiative, but after his death Marie Neurath edited, wrote, and designed a large number of children's educational books, some of which were schoolbooks. Children's book series included *If you could see inside*, *I'll show you how it happens*, *Visual history of mankind*, *Visual science*, *Wonders of the Modern world*, and *Wonder world of nature*. The Isotype institute delivered both the text and design for these books. Illustrations would include pictograms and all kinds of explanatory drawings. In another series, *They lived like this*, the majority of the illustrations were drawings of contemporary artefacts. This series was co-written by external artists.

Marie Neurath's thoughts about the work with children's books are interesting to everyone working with data visualisation:

> I had to ask myself: what are the essential things we want to show, how can we use comparison, direct the attention, through the arrangement and use of colour, to bring out the most important things at the first glance, and additional features on closer scrutiny. Details had to be meaningful, everything in the picture had to be useful for information. (p.395)

From a note addressed to the readers of the second book in the Visual history series:

> Everything which would not help you understand the meaning, or which would confuse you, is left out. Colours are used only to help make the meaning clearer, never simply as decoration. This means that every line and every colour in these pictures has something to tell you. (p. 403)

USA

Three factors obstructed Isotype's introduction into the USA. The timing was not good. It was the middle of the depression, there were several imitators (just competitors?) around, and there was Rudolf Modley, a former part-time employee in the administration of the Gesellschafts- und Wirtschaftsmuseum in Wien. Rudolf Modley would cooperate and compete with the Isotype team in Den Hague and Oxford, and challenge Otto Neurath's views.

A group of influential supporters worked together to get Otto Neurath and Isotype to the USA. When in 1930 there was an opportunity to use Isotype at the Museum of Science and Industry in Chicago, Otto Neurath recommended the employment of Rudolf Modley. Here and later Modley acted more independently than envisaged by Otto Neurath.

In 1934 the supporters founded the Organizing Committee for the Institute for Visual Education "to establish in the United States an organization which can develop and promote the graphic methods of presenting social and economic facts, which have been characterised by the Vienna Method as exemplified in the work of the Gesellschafts- und Wirtschaftsmuseum in Wien under the direction of Dr. Otto Neurath" (p. 307). When the organisation did not follow Modley's advice, he created his own company, Pictorial Statistics Inc. Otto Neurath and Rudolf Modley held differing views. Neurath wanted standardised pictograms designed centrally while Modely had a more relaxed view. Neurath explained:

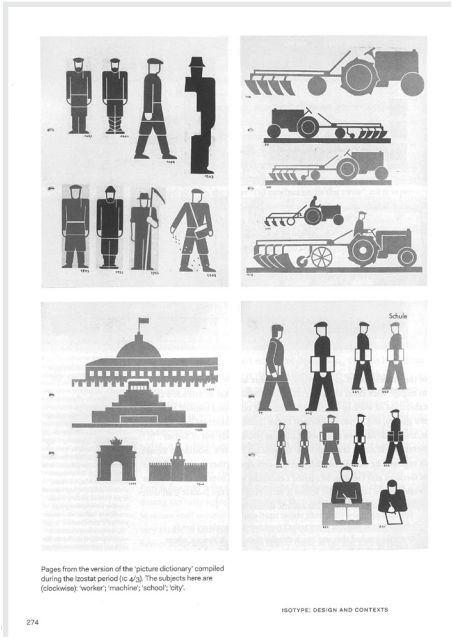
> That is to say, for our picture language one general list of a limited number of signs is needed for international use, and this has to be worked out by or under the control of one chief organization (This organization is now the ISOTYPE work-room at the Hague). (p. 332).

Also, Modley saw the pictograms as elements that could have their own life while Neurath saw pictograms as parts of visual arguments enabled by transformation. Modley was not interested in transformation. In line with this view he published symbols sheets with pictograms to be used by everyone and a book entitled, *1000 Pictorial Symbols* (1942).

Otto Neurath travelled to the USA several times and secured important commissions, primarily in the health sector. Isotype also delivered illustrations to *Compton's pictored encyclopedia* (1939) and Otto Neurath wrote *Modern man in the making* (1939) for Knopff publishers. After Neurath's death Marie Neurath wrote an essay on Isotype for Henry Dryfuss's *Symbol Source Book* (1972).

RUSSIA

The Isotype team's efforts in Russia took place from 1931-1934. Russia did not want to commission Isotype work from Vienna. Instead, they wanted Isotype staff to help establish a Soviet institute. A special organisation named Izostat was established with Otto Neurath as one of two directors, and several Isotype staff would join them for shorter or longer periods. The total staff at times would be as high as 75. A number of problems hindered cooperation. The work primarily dealt with visualising the established success of the first five-year plan 1928-1932 and the predicted success of second five-year plan 1933-1937. While The Vienna Method as practiced in Vienna was based on empirical facts, the Russians wanted forecasts to play an essential role. The estimates were often exaggerated. Another problem was that the Russians wanted naturalistic pictograms aligned with wanted Soviet realism. Also, the Russians wanted more, sometimes propagandistic, illustration. The cooperation resulted in some publications with more or less Viennese influence. Georg Arntz made a series of charts for Izvestia, charts for exhibitions, and a number of publications more or less influenced by the Isotype team. One Isotype idea was used with a new meaning. In the Vienna Method black was sometimes used to illustrate worse, while red would stand for better. In Russian charts red would stand for Russia while black would stand for other nations.



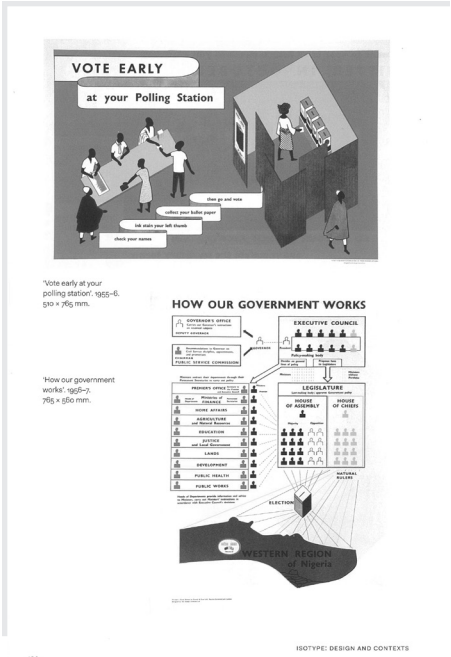
Page 174
Isotype work for Izostat in Moscow characterised by Russian realism.
(original in color)

In 1934 the Russians wrote to Otto Neurath that the contract did not comply with Russian law and the amount due at the end of the contract would not be paid. The latter incident was a major blow to the Isotype organisation, which in Den Hague depended on paid work. Izostat continued without Isotype help until 1940.

AFRICA

Some Isotype work in Africa took place from 1952-1958. Otto Neurath reportedly said that Isotype was not for the Viennese, but for the Africans (p. 449). In 1943 he worked on a proposal for an exhibition for the British Colonial Office entitled, *Human life in Africa*. This project did not materialize.

In 1953 a partnership between Buffalo Books, a subsidiary of Adprint, the Isotype Institute, and Purnell and Sons, a printing firm, planned and published the magazine *Forward* addressing the three British colonies Gold Coast (Ghana), Sierra Leone, and the Western Region of Nigeria soon to become independent. A trial issue and an issue number 1, dealing with culture, adventure, sports, and practical advice were published before the magazine was determined to be economically impossible in 1953.



'Vote early at your polling station', 1955–6. 510 × 765 mm.

'How our government works', 1956–7. 765 × 560 mm.

Page 480
Isotype work with limited abstraction for Western Region, Nigeria, promoted participation in an upcoming election. *(original in color)*

In 1954 Marie Neurath wrote a memorandum sketching what Isotype could do in the Western Region of Nigeria. It included a visual explanation of the aims of the government and the establishment of a local workshop for Isotype run by trained Nigerians. Marie Neurath visited Africa three times and a series of booklets and poster-leaflets were produced, while the workshop remained a plan.

For the Western Region a series of 16-page White Paper Booklets were published including *Education for all in the Western region*, *Better farming for better living in the Western Region*, *Health for all in the Western Region*, and *Paying for Progress in the Western Region*. Also a series of poster-leaflets dealing with health issues was produced. As indicated by the name, the poster-leaflets worked both as wall charts and as folded leaflets to take away. A following visit to the Western Region resulted in commissions for a new series of booklets.

Compared with the Western Region in Nigeria the Gold Coast and Sierra Leone had little work for Isotype. In 1956 Isotype made one leaflet for The Gold Coast, *The Volta River Project: what it means to you*, and in 1957 one for Sierra Leone *Voting, general election*.

In the late fifties the Isotype work in Africa came to an end. The chapter author, Eric Kindel, offers a number of probable explanations, one being the distance, another being the failure to establish a local workshop with trained local people. To the Isotype Institute the African experience meant realising the need for locally adapted symbols for man, woman, house, and more. The pictograms should 'speak'. In the same vein, charts were given familiar backgrounds. According to Marie Neurath: "[A]dherence to the method cannot go as far as imposing an alien background on those unable to share one's experience of it." (p. 495). This did not, according to Marie Neurath "imply that the system had to be radically changed" (p.495).

DESIGN

In the second central chapter of the book, Robin Kinross presents the design of Isotype. This chapter was originally a part of Kinross's MPhil thesis from 1979. (Robin Kinross is the owner of Hyphen Press, the publisher of this book as well as Otto Neurath's 'visual biography': *From hieroglyphics to Isotype* (2010) and a string of well presented books on typography.) The provenance of the chapter may explain the order in which it deals with the subject. The description begins with the formats of the wall charts, and moves through

colour, male and female, qualifying symbols, and guide pictures, down to pictograms and configuration. In the latter part Kinross codifies six types of displays dealt with by Isotype. This would have been a natural start of the chapter to be followed by pictograms. Apart from this peculiar arrangement the chapter gives a robust description of the elements used in Isotype. Kinross calls Isotype "a coherent approach to ordering material in graphic form" (p.107). It covers what we today call 'data visualisation'. In contrast to the remaining part of the book, Kinross offers a few critical remarks on Isotype.

Considering Neurath's interest in education it is remarkable that there exists no manual, no single, document explaining the Isotype design principles thoroughly. One reason could be that Isotype remained a work in progress. Another reason could be that Neurath did not want everyone to design visual displays, but rather to commission the displays from the initiators. So-called notes, single sheets each describing a design subject, were descriptive rather than prescriptive. They described current practice more than recommending what should be done. Also, Neurath's publication, *International Picture Language*, 1936, written in Basic English doesn't serve as a manual either.

Kinross's description of Isotype design gives a clear impression of Isotype being a work in progress. Pictograms, qualification, grouping of pictograms, use of colour, use of typography, and configuration would change considerably between 1925 and 1934, especially after Georg Arntz joined the team. However, this development did not always follow a straight line. Different principles were sometimes used concurrently; old design features were sometimes used after new design features were introduced. The development involved standardization, modularization, and simplification. Pictures would be reused and be combined; the use of colours would be restricted.

Kinross refers to the common misunderstanding that "quantified rows and columns" "might be typical of the work as a whole" (p. 142). Well, these picture tables and their pictograms are what most of us think about first when we think about Isotype. The picture tables and their pictograms are featured on the covers of publications and wherever Isotype is discussed. Kinross shows the width of Isotype by the following classification (p. 139).

Charts showing quantified material:

1. rows and columns [picture tables],
2. division of a whole (usually a checker-board),
3. geographically ordered pictograms and more diagrammatic charts,
4. quantities related to area (usually showing densities),
5. flows.

Charts showing non-quantified material:

Neurath broke down the picture table category into six sub-categories (p. 140):

1.1 comparison of total quantities,
1.2 where sizes of constituent parts are interesting, as well as total quantities,
1.3 where relative sizes of constituent parts are most important,
1.4 to make a shift particularly clear; alignment left and right to form an axis,
1.5 where the sizes of parts and of wholes are equally important; one compares both horizontally and vertically,
1.6 to allow comparison of parts and wholes, and to make a shift clear; especially important in showing changes over time.

A schematic drawing and an Isotype picture table illustrate each of these sub-categories.

While the fact that a large part of the text of this chapter is devoted to picture tables and pictograms may support the idea that Isotype first and foremost is picture tables, the book's numerous illustrations establish some balance. Isotype is both picture tables and a general approach to data visualisation.

In a chapter about pictograms, Christopher Burke confirms that a direct line from the Isotype pictograms to the pictograms used in transport and communication today hardly exists. However, qualities such as standardization, modularity, and schematization are parts of the Isotype heritage. Isotype pictograms worked in lines in picture tables to compare something, while modern pictograms in transport and communication simply point to the existence or condition of something. Otto Neurath, however, suggested that the Isotype pictograms could possibly also be used for public information signs. This application was not realised.

WHY NOT?

Isotype: Design and contexts 1925–1971 is a comprehensive introduction to the Isotype idea. The book's 12 chapters written by nine authors are well planned with a minimum of overlaps. While the main text goes into considerable historical detail, the illustrations present the elements and charts by which Isotype should be known and appreciated. The numerous illustrations – more than 400 – and their elaborate captions turn the book into a portable archive, which for everybody unable to access the Isotype collection at University of Reading will remain the most important Isotype resource.

Implicitly the book relays a well-known phenomenon: how a design idea born to solve one problem if successful becomes a

solution that looks for other problems. From informing the Viennese citizens the problem changed into finding potential outlets for the newfound method.

In the beginning of *Isotype: Design and contexts 1925–1971* Christopher Burke states, "The best way to bring these [the qualities of Isotype] to the fore is to examine it as a historical phenomenon in all the complexities of its contexts." (p. 14). This is questionable. To compare is the basic function of Isotype. Isotype should itself be compared with competing data visualizing formats. How can we evaluate the virtues of airships without comparing airships with other airborne vessels?

We still need a balanced discussion of the qualities of Isotype. What exactly is the Isotype approach? How does it survive today? How does Isotype compare with the display formats that news media and others prefer today? What are the pros and the cons of Isotype compared with other more frequently used data visualising formats such as bar charts, bubble charts, and line charts? Understandability, accuracy, attraction, and memorability are factors that should be discussed. The discussion should also include the intended target groups of Isotype and the contemporary audiences of news media and professional literature. Is Isotype only for uneducated people?

One probable finding is that most contemporary audiences prefer exact information to the visual explanation offered by Isotype picture tables. Today bar charts, pie charts, and bubble charts, which in principle present *visual* messages, are as a rule supplied with exact figures. Such displays are hybrids. They are half visual display, half table. The visual part lets the reader get a fast idea, while the figures deliver accuracy. In a short period Isotype's picture tables were also supplied with exact figures. In later displays the figures were abandoned. The big, undisputable advantage of isotype displays is that they are attention grabbing and attractive to look at. The visual attraction may be accompanied by good memorability.

P S

Design and contexts 1925-1971 is well crafted with a pleasing design. However, there are two minor flaws. First, the key to source abbreviations is located on page 18, while readers expect to find it in the beginning of the book where it would be easy to retrieve for later reference. Second, tiny, alphanumeric caption designations of up to four characters are written with lowercase numerals (6 and 8 with ascenders and 3, 4, 5, 7, and 9 with descenders), which are difficult to read, especially when presented in the very small type used for marginalia.

Per Mollerup
14 August 2014

THE MOST IMPORTANT DESIGN BOOKS MOST DESIGNERS HAVE NEVER READ:*

The Case for Mental Imagery

by

Stephen M. Kosslyn, William L. Thompson, and Giorgio Ganis

Mike Zender

date: 2035 CE
location: a design office

The designer looked at the screen and watched the child's memory of being sick. "I'm sorry to ask you this, but think of diarrhea again please," she said. The toilet shimmered into view briefly followed by transparent wavy lines. The designer noted the lines, then replayed the other children's memory and noted that 67% of them included shimmering, wavy lines to represent smell. "Thank you, that's all I needed. You've really helped me design this icon," she said.

Paul Rand once said that communication design is about "saying the commonplace in an uncommonplace way." (Rand, 1970, p. 36) This suggests that effective communication is essentially enhancing the familiar. For visual communication design, this means creating unique images that will connect in predictable ways with the images people already hold in their minds. From this perspective, the whole user-centered design movement is a cultivation of means for designers knowing, not just assuming, the mental images people have. Stephen Kosslyn, William L. Thompson, and Giorgio Ganis' book *The Case for Mental Imagery* (Kosslyn, Thompson, & Ganis, 2006, p. 4) gives designers an accurate glimpse into how mental images work.

MENTAL IMAGES

The plausibility of the fictional design office above hinges on the answer to a debate that has raged for at least decades, perhaps centuries: do we see mental images or not? According to Kosslyn, Thompson , and Ganis, "A mental image occurs when a representation of the type created during the initial stages of perception is present but the stimulus is not actually being perceived." Mental imagery is seeing what is not there, not an illusion or a mirage, but seeing in our mind something familiar and then perhaps using that mental image to think with or solve a problem. We might experience this by answering this question: how many windows face the street in your house or apartment? Given this task most people gaze blankly for a second

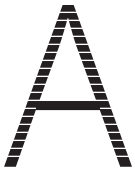
or two as they push into memory an image of their house and then briefly count the windows in the image. Kosslyn et. al. cite similar questions such as "Do you know which is darker green, a frozen pea or a pine tree? Or the hand in which the Statue of Liberty holds the torch" as examples where people use mental imagery.

Belief that this phenomena exists are not new. The authors briefly note that thinkers from the classic Greeks to Einstein claimed to use mental images "in memory, problem solving, creativity, emotion, and language comprehension." However, introspective experiences are notoriously difficult to study, easy to refute, and thus ripe territory for endless debate. Kosslyn, Thompson, and Ganis use Chapters 2 and 3 to detail the debate, Chapter 4 to marshal empirical findings from a broad range of cognitive psychologists and neuroscientists in order to settle the debate, and Chapter 5 to articulate a well-founded theory of mental imagery.

The theory articulated in the book is based on the process of visual perception which it describes. The eye is just the start of a process that occupies much of the brain. In fact, approximately 50% of the cerebral cortex is devoted to visual processing. The brain is not like a general-purpose computer with generic processing capacity to which are downloaded different problems for analysis. Rather, the brain is like a special purpose device with different neurons in different regions hard-wired to accomplish specific tasks. Vision is one of the brain's largest tasks. In visual perception a huge volume of sensations are processed and reduced to simpler more organized forms. It's as if individual camera pixels are processed for simple features then structured into units that correspond to distinct objects and key properties that define and distinguish those objects from each other. Kosslyn and his colleagues propose that we can reverse this process and push the abstracted memory of a visual object backward onto the brain's early visual processing areas and there mentally re-construct a representation of something. Representation is a key idea here. The authors point out that stored depictive representations are not like photographic pictures. They are simplified forms that can be re-presented and then examined and to which detail can be added. It may help communication designers to think of these abstracted representations as "brain icons" because they, like drawn icons, are simplified and focus on key features of an object or idea rather than inessential details. We can use these mental images to reason about problems, like whether a jar could squeeze into a crowded pantry shelf, or to communicate with people by creating images that connect with their visual imagery. It is important to note that understood this way, there is a deep and complex relationship between seeing and thinking that deserves attention.

COMPETING THEORIES

Kosslyn et. al. identify the core of the debate as two competing conceptions of the format we use to store internal visual representations: depictive



Depictive format above

FIGURE 1

FIGURE 2

Propositional format below

"two diagonal lines that meet at the top, joined halfway down by a short horizontal segment."

(Kosslyn et al., 2006, p. 12)

or propositional. The depictive approach suggests that our brain encodes images in a visual format using points, similar to the way a computer screen uses pixels. The blocks forming the triangle in Figure 1 illustrate a depictive format. The propositional approach suggests that we format images using abstract concepts like words in language or computer software. The words "two diagonal lines that meet at the top, joined halfway down by a short horizontal segment." in Figure 2 illustrate a propositional format for the same image.

The format used may seem like an academic debate, but it matters because the format of representation makes possible, or at least preferences, different kinds of thinking and from this the creation of different knowledge.

To settle the debate the authors call upon findings that add significant detail to the outline of the perceptual process noted above. Very early in this process the image from our retina is topographically mapped point-for-point on our brain. Objects close to each other on our retina are also close to each other on the cortical area called V1. There are, in fact, several topographically organized layers in V1 with each layer providing different kinds of processing. Cutting down through layers are columns that distinguish different line orientation, curve, value, and hue. These topographic layers are part of what Kosslyn labels the "visual buffer." The "visual buffer" then "reports" the results to other areas of the brain where patterns and shapes are assembled, where objects are formed and subsequently identified. Kosslyn asserts that through these successive stages a "population code" is assigned containing in abstracted form the key visual features that define an object. Kosslyn posits a "hybrid representation" that combines information for each point about its role in the depiction of the object, as well as additional abstracted information. "In spite of their coding nondepictive information, these hybrid representations cannot be reduced to propositional representations. Crucially, they use space (literally, on the cortex) to represent space in the world. The fact that each point codes additional information does not obviate its role in depicting the shape."

The highlight of Kosslyn's argument is that these encoded representations can be recalled and when they are, an image is reconstructed from memory using the same topographic neural space in the "visual buffer" that was used to "see" the initial image from the eye. In Kosslyn's words, the "stored shape representation is primed so strongly that activation is propagated backwards, including a representation of a part or characteristic in the visual buffer (which corresponds to the depictive image itself)." Kosslyn theorizes that we literally re-construct the object from memory and create a representation of it. These are mental images.

VALIDATION

When Kosslyn and his colleagues wrote this book some years ago the viability of their theory was still open to debate. But much has happen since then to support its basic premises.

In 1988 Tootell et. al. provided a foundation for how we see when they showed a topographically represented visual image mapped on the surface of a primate brain. Over the years various scientists have developed techniques that enable them to dye a primate brain and see there on the cortex - in real time - the images from the eye. A 2012 NIH presentation by Dr. Eyal Seidemann is one example of video showing this. ("Decision Related Activity and Top-down Attentional Modulations in Primate VI" http://videocast.nih.gov/summary.asp?Live=11769&bhcp=1) More recently researchers used fMRI to produce an image of a person's recalled memory (mental image) of a simple object. In 2014 Dr's. Cowen, Chun and Kuhl presented findings that through observing brain activity they were able to reconstruct recognizable individual faces from people's mental images of faces they were seeing ("Neural portraits of perception: Reconstructing face images from evoked brain activity" in *Neuroimage).* The title of the March 28, 2014 Fox news article reporting this paper was *"We know what you're thinking: Scientists find a way to read minds."* by Maxim Lott. While the face reconstruction study may be as much about the inventiveness of the computer processes employed as it is about the biological ones, its findings dramatically support the foundation of Kosslyn's hypothesis: mental images are seen reconstructed in the visual buffer. These studies can "see" them.

SO WHAT?

The Case for Mental Imagery may sound interesting to some readers, but to others the question "So what?" may have been lingering for some time now.

So what? How is the information in this book relevant to the designer? One answer is "A theoretical foundation for communication design." Communication design has entertained competing theories to guide practice. Some, such as semiotics, are based in linguistics. Theories of visual perception such as the one articulated by Kosslyn, Thompson, and Ganis may help provide more appropriate visual ground for a theory of visual communication. Knowing how people process, store, and use images is at the heart of visual communication. It's true that communication designers create objects that use both textual and visual forms to communicate and much has been written recently about the role of designer as author and the need for more writing in design education. Without dismissing the positive role designers can play in crafting the written content of the communication they create (designer as author), or diminishing the role writing can play for organizing and expressing thought in design classes (writing in design education), Kosslyn's theory suggests that there is a good reason that college "communication" programs focus on writing while "visual communication" programs focus on image making. Visual images are the essence of visual communication. Communication designers employ forms of communication that largely bypass language. Kosslyn reminds us that people think with images. One benefit of

Kosslyn's theory as it applies to design is that it is founded on hard-wired neurobiological perceptual processes common to all people, suggesting that design principles founded on this approach may be universal, applying to people of every age, language, literacy level, and culture. With limited research resources to invest, design might do well to focus on universal visual processes that can apply to nearly everyone before building upon theories focused on individual differences.

In addition to providing a theoretical foundation for visual communication, "Visual thinking" is another defense of the book's relevance. Kosslyn's theory, based as it is on depictive representations, means that visual designers use a visual language that is inherently more flexible and less inhibited by arbitrary encoding structures than language. Depictive reasoning can be more ambiguous and less structured than propositional reasoning. Images are more direct, less categorical, less overtly defined, and thus better suited for creative thinking and problem solving than language-based propositional representations that seem plodding by comparison. "I see" is a common visual-based metaphor for sudden understanding and an apt metaphor for visually-empowered design thinking.

"User centered" is yet another response. Kosslyn's theory means that communication designers now and in the future can reliably identify the mental images that people have, thus gaining direct insight into how to communicate with them more accurately. Designers who know their subjects' mental images can more reliably produce images that evoke the correct meaning. Knowing people's mental images moves user-centeredness into the user's head, literally. The point of view for designers might be transformative.

"Evidence-based" is another reply. Kosslyn's theory doesn't just apply to the front end of design creation, but also to the back end of design evaluation. Using people's mental images to evaluate communication objects could give not only very accurate measurement of communication but insight to corrective action. A loop of creation and evaluation based on reliable measurement of mental image may provide communication design with some solid principles for practice.

Another Paul Rand quote suggests a final answer when he states, "…the designer must steer clear of visual clichés by some unexpected interpretation of the commonplace." "Innovation" is the final answer. Design has been said to be the process of converting existing states to preferred ones. Designers don't just create what already exists; they create something new. So how can knowing the images people already have in their heads help create something new? To a designer the question is the answer. Knowing what people think enables us to take liberties, to explore novel variations and "unexpected interpretations", to both connect and expand what is in people's minds. Apart from knowing the people's mental images designers innovate in the dark, ignorant of whether their novel approaches support or hinder communication.

Kosslyn, Thompson, and Ganis' theory means several things to communication design. It means that seeing and thinking are complementary, helping to explain the effectiveness of information visualization. It means that visual communication designers who create images are directly connecting to the one of the most significant means people have for processing information, for thinking. It means that emphasis on visual thinking is one key to why design is good at creative problem solving.

If design theories should be founded on research findings in visual perception and cognition, then they will in some measure be founded on work by Kosslyn and his colleagues. It's a book that most designers should read.

Cowen, Chun, & Kuhl. (2014). "Neural portraits of perception: Reconstructing face images from evoked brain activity." Neuroimage

Kosslyn, Stephen M., Thompson, William L., & Ganis, Giorgio. (2006). *The Case for Mental Imagery*. New York, NY: Oxford.

Rand, Paul. (1970). *Thoughts on Design* (Third ed.). New York: Wittenborn Schultz.

Advisory Board

WELCOME

Visible Language wishes to welcome new advisory Board member Keith Crutcher. Keith reflects our interest in connecting to disciplines whose research is well-advanced and whose knowledge is related to visual communication.

Keith Crutcher

Keith A. Crutcher, Ph.D., has over 30 years of experience in biomedical research and technology including prior tenured faculty appointments at the University of Utah (7 years) and the University of Cincinnati (22 years), a founding role in an early stage drug discovery company (ApoLogic, Inc.), and four years serving as a Scientific Review Officer at the Center for Scientific Review at the National Institutes for Health. In the latter role, he managed the peer review of hundreds of grant applications. His academic research program, funded by the NIH, NSF, and other agencies, included studies of brain injury and Alzheimer's disease resulting in over 100 peer-reviewed publications, two issued patents, and numerous presentations. He has also served as an ad hoc reviewer for several federal agencies and private foundations as well as serving on the editorial boards of several journals including *Experimental Neurology*, *Aging Cell*, and *Neurobiology of Aging*, where he participated in the peer review of numerous manuscript submissions. He currently does consulting work for applicants seeking research funding and provides assistance in preparing proposals and navigating the peer review system at various federal agencies.

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Before there was reading there was seeing. *Visible Language* has been concerned with ideas that help define the unique role and properties of visual communication. A basic premise of the journal has been that created visual form is an autonomous system of expression that must be defined and explored on its own terms. Today more than ever people navigate the world and probe life's meaning through visual language. This journal is devoted to enhancing people's experience through the advancement of research and practice of visual communication.

If you are involved in creating or understanding visual communication in any field, we invite your participation in *Visible Language*. While our scope is broad, our disciplinary application is primarily design. Because sensory experience is foundational in design, research in design is often research in the experience of visual form: how it is made, why it is beautiful, how it functions to help people form meaning. Research from many disciplines sheds light on this experience: neuroscience, cognition, perception, psychology, education, communication, informatics, computer science, library science, linguistics. We welcome articles from these disciplines and more.

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Website
http://visiblelanguagejournal.com

Postmaster:
send address changes to:
circulation manager name
Office of Business Affairs
College of Design, Architecture, Art, and Planning
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016

Published tri-annually in January, May and October

SUBSCRIPTION RATES

United States	Individual	Institutional
1 year	$35.00	$65.00
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1 year	$ 56.00	$ 86.00
2 year	$107.00	$166.00
3 year	$153.00	$246.00

Prepayment is required. Make checks payable to University of Cincinnati *Visible Language* in U.S. currency only, foreign banks need a U.S. correspondent bank.

* Canadian subscriptions include additional postage ($9.00 per year).
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ISSN 0022-2224
Published continuously since 1967.
Index included in last issue of volume year.

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Visible Language

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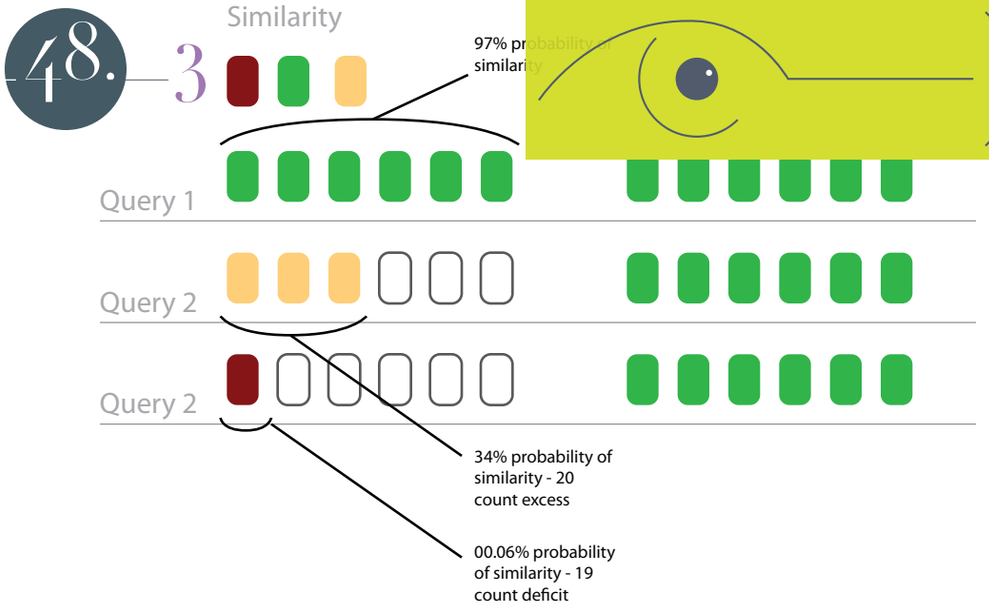
November 2014



visualization logic

50% – 100% probability of similarity = green

5% – 50% probability of similarity = yellow

less than 5% probability of similarity = red

six boxes filled in proportion to show inter-hospital similarities
six boxes need to show probability over/under 50%
six boxes can be rapidly enumerated (in about 1 second)

A Statistical Approach for Visualizing the Quality of Multi-Hospital Data

Connolly et. al.

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education theory

design principle

drill

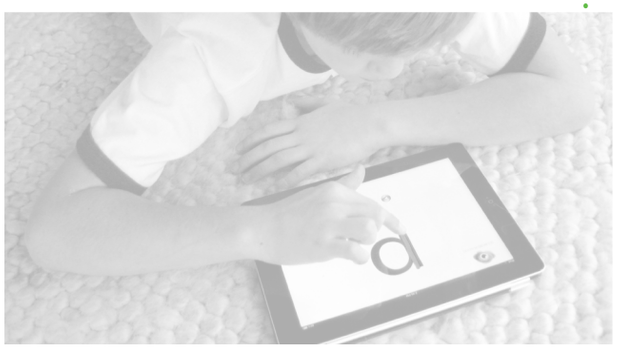
listen to sound

tactile

responsive

interaction

usability



universality

visibility

memorability

drag&drop

mnemonics

first-sound

Linking Design Principles with Educational Research Theories to Teach Sound to Symbol Reading Correspondence with Multisensory Typea

Seward et. al.

individualized

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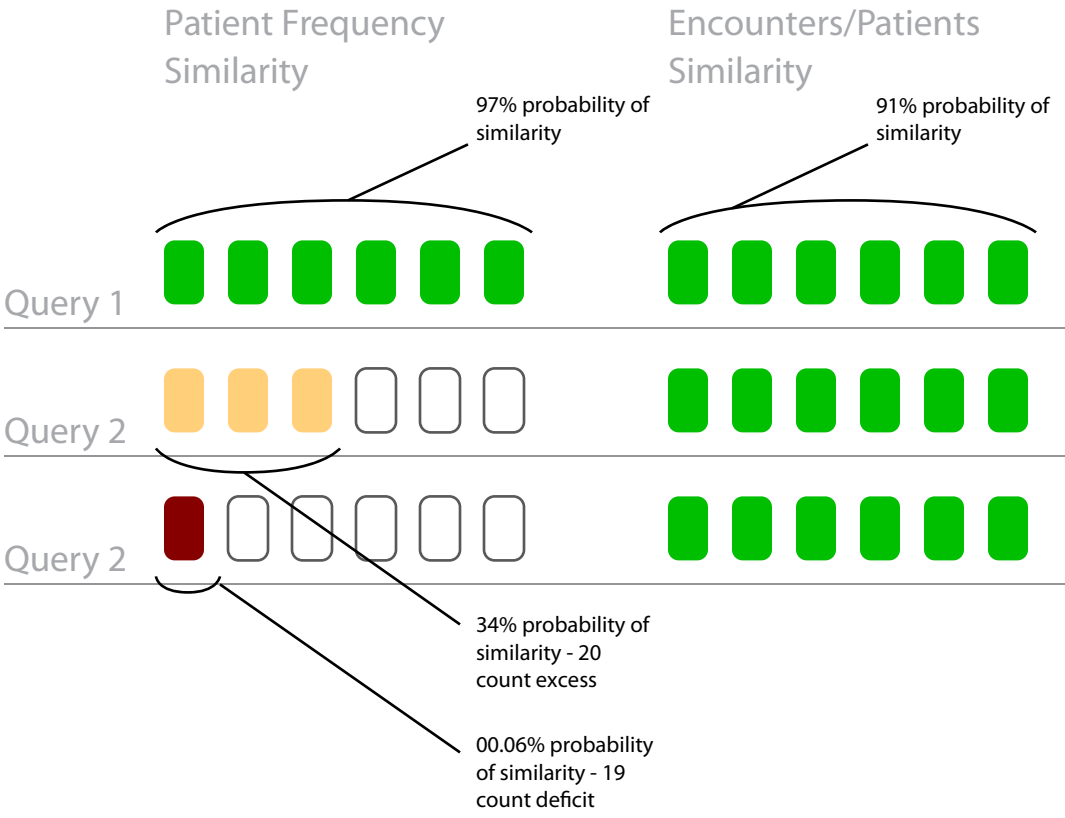
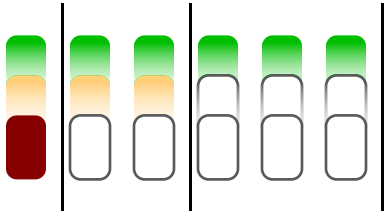


visualization logic



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see *figure 1a* for details

A Statistical Approach for Visualizing the Quality of Multi-Hospital Data

3

Brian Connolly, Robert Faist , Constance West, Katherine D. Holland, Pawel Matykiewicz , Tracy A. Glauser, and John Pestian[1]

Cincinnati Children's Hospital Medical Center, Cincinnati OH USA

[1] corresponding author: 3333 Burnet Ave., MLC 7024, Cincinnati, OH 45229-3039, phone: 513-636-1627, fax: 513-636-2056, john.pestian@cchmc.org

ABSTRACT

The age of Big Data and the associated proliferation of large data sets have necessitated the development of methods that allow for an easy interpretation of data analysis results. Such methods are usually the product of a symbiotic relationship between the fields of data visualization, infographics, and statistics. In this work we explore the interplay between data visualization and the mathematical framework used to analyze inter-hospital differences in database queries. Such differences can reflect disparities in the quality of care or more fundamental disparities in data quality. As the volume of queries is large and increasing, it is important to develop an incisive way of visualizing these differences. Specifically, we demonstrate the importance of choosing a mathematical framework that calculates the statistics necessary to visualize the results in a maximally concise and intuitive way. We derive symbolic statistical representations of inter-hospital query differences using a Bayesian probabilistic formalism to indicate statistically significant discrepancies. These statistical representations serve the need for visual representation of differences and their meaning apart from statistical expertise. The calculations were performed with a publically-available package, DQM, available at http://sourceforge.net/projects/databasequalitymanagement.

KEY WORDS

visualization, statistical methods, Bayesian analysis, data display, information display

1 INTRODUCTION

1. BACKGROUND

Analyzing large data sets presents a unique set of challenges, one of which is presenting results in a concise, easy-to-interpret way. In this work, we explore the impact of selecting the right mathematical framework that can be used "behind the scenes" to fully unveil the information potential of data visualizations.

The methodology described in this work is demonstrated within the context of healthcare. The healthcare system is under pressure from private citizens, businesses, and government to reduce costs while simultaneously improving patient safety and outcomes. Healthcare organizations have the opportunity to leverage Big Data technology to utilize the wealth of information generated during patient encounters with providers, pharmacies, hospitals, and social agencies. However, much of the clinically relevant information, including physician and provider notes, laboratory and imaging results, correspondence, and insurance claims data, is unstructured and thus quite complex to analyze. Theoretically, the aggregated data may be used to understand disease and to manage both individual and population behaviors. It is reasonable to expect that information from that data will drive efficiency and economy in healthcare consumption and delivery.

One of the difficulties in aggregating data from multiple organizations or populations is understanding the similarities and differences in the prevalence, severity, and presentation of a particular disease or condition in the populations of interest. A cursory evaluation suggests that there is considerable variation between providers in the treatment of even the most common adult and pediatric conditions. For example, children in Lebanon, New Hampshire are more than twice as likely to undergo a tonsillectomy as children less than 200 miles away in Bangor, Maine (The Dartmouth Atlas Working Group, 2013). Similar variations in adult surgical care have been reported by Birkmeyer et al. (Birkmeyer et al., 2013).

In this work, we compare database queries requesting data on epilepsy patients from three hospitals: Cincinnati Children's Hospital Medical Center (CCHMC), Children's Hospital of Philadelphia (CHOP), and Children's Hospital Colorado (CHCO). It is important to identify inter-hospital variations in such queries, as they can not only reveal differences in patient care but also more fundamental differences in data quality. Such differences can make it difficult to perform meaningful inter-hospital comparisons of patient care. To facilitate understanding one might wish to develop a concise and intuitive visualization scheme that identifies and qualifies the differences.

The queries themselves take the form of searches for "facts" within the database. For instance, a search for the fact "age" returns the number of patients for whom their age was reported. Although

the query results do not give specifics as to what was reported, the search for a fact itself can reveal important information. For example, the search for "Diagnostic testing / Neuroimaging / MRI" that returns non-null results indicates that MRI neuroimaging was performed.

For each hospital, a query generally returns two numbers: the patient frequency (PF), and the total number of encounters over all patients for a given time period. The PF is the number of patients for whom a certain fact was reported. The number of total encounters accounts for all of the total documented patient contacts. A "patient contact" refers to every possible encounter, including outpatient visits, surgery, telephone calls to/from providers, and prescription refills.

The PFs are, of course, different among hospitals, as hospitals treat different numbers of patients. If the hospitals operate similarly, then a query should extract, within statistical fluctuations, the same percentage of patients from each hospital. Therefore, determining whether or not the PFs from a query are "different" among hospitals is to determine whether or not there is a statistically significant difference between the distribution of total patients over the hospitals and the distribution of patients in the queries. Using an example to illustrate, suppose three hospitals see 1,000, 2,000 and 3,000 patients in a month, respectively. Queries are run, and it is found that 100, 200 and 300 patients received MRI's from the three hospitals, respectively. Comparing the ratio or distribution of total patients over the hospitals, 1,000:2,000:3,000, to queried patients, 100:200:300, it is trivially apparent that there is no statistically significant difference between them. Note that this procedure is the same as comparing the percentage of patients that have had MRIs in the hospitals; in practice, however, ratios of PFs are compared. Of course a given query regarding epilepsy patients is not performed over every treated patient. Rather, a query is performed on a "base pool" (BP) of epilepsy patients.

The total number of encounters can also be different among hospitals. In understanding inter-hospital differences, the number of encounters by itself is less interesting than the encounter-to-patient ratio (EPR), or the number of encounters per patient. Note that the encounters are counted over a certain time period, so it is assumed that the query is made over the same time period for all hospitals. Unlike PFs, the EPR is expected to be the same across hospitals if the hospitals operate in a similar manner with similar types of patients. Finding inter-hospital differences using the EPR is then a matter of simply comparing the ratio of total encounters to total patients in the hospitals. For instance, if three hospitals have 300, 400 and 500 patients in their BPs, and a total of 600, 800 and 900 encounters over those patients, then the encounter-to-patients ratios for the three hospitals would be 2:1, 2:1 and 4.5:1, respectively. The ratio of the third hospital is different from the other two; however, we would have to evaluate whether that difference is statistically significant using the formalism described below.

To begin to understand inter-hospital query variations, one would like to know whether the differences in the PFs or EPRs are statistically significant. It is also desirable to visually represent the meaning and magnitude of the differences found.

There are a number of approaches to quantifying the differences and similarities in a set of numbers. One of the most obvious methods is significance testing using the χ^2 statistic, which can be used to reject the hypothesis that the PFs or EPRs are similar. However, significance testing depends on the calculation of p-values, which notoriously underestimate Type I error rates (Sellke et al., 2001). This underestimation of "false positive" results stems mainly from a lack of consideration of the alternative hypothesis. Also, many of the queries discussed are plagued by low statistics; for small data sets, the χ^2 method would simply fail to reject the hypothesis that the PFs or EPRs were the same and give no information concerning the degree to which they were similar.

The maximum likelihood ratio (LR) method is a technique that avoids some of the pitfalls of the χ^2 technique, as it considers the likelihoods of both similarities and differences. However, it cannot directly quantify the likelihood that the PFs or EPRs are different because such a hypothesis does not exist for the LR test.[1]

1 For the same reason the hypothesis ``the coin is not fair'' cannot be quantified within any frequentist approach.

The two tests described above are examples of frequentist approaches to statistical inference, and their failures are endemic to the frequentist approach in general. On the other hand, the Bayesian formalism, derived from logic (Cox, 1961), circumvents the flaws of the frequentist methods by using a direct calculation of the probability that, for example, the EPRs are consistent within statistical uncertainty across different hospitals. More importantly, it calculates a maximally intuitive statistic measure that can be easily interpreted with no statistics expertise. Although it is not the main purpose of this work to argue the value of the Bayesian formalism over other approaches, we demonstrate an instance where the Bayesian approach matches our aim to visualize intuitively whether PF's and EPR's are different, as well as the meaning and magnitude of any differences that exist.

This paper describes our journey from visualization need to the Bayesian mathematical formalism that supports it. Our procedure compliments the common initial step of determining the visualization technique from the represented objects and operations (Wehrend and Lewis, 1990) or through data types and the task-domain information actions that the user wishes to perform (Shneiderman, 1996). Instead, we start with a visualization need and find a statistical method to support it. The work here is most similar to Tukey's exploratory analysis (Tukey, 1977), which includes visualization techniques to extract potentially useful hypotheses from data. In this work, we describe a procedure of determining the details of the hypothesis-based data manipulations necessary to meet the visualization goals, which are anomaly identification tasks in the taxonomy of Amar et al. (Amar et al., 2005). Such a procedure would not be necessary in the instance

where the visualization scheme follows directly from the information to be visualized. For instance, Farrah et al. (Farrah et al., 2009) used a mathematical framework similar to the one described here in order to quantify the similarities and differences in galactic spectra. In their case, the sheer volume of data and the nature of the comparisons begged for a certain visualization scheme (a network diagram). Likewise, Zender et al. (Zender et al., 2010) presented a Visual Language System to represent (complex) concepts in medicine; the system used icons and glyphs to ease the interpretation of raw data. In contrast, a methodology like the one described here would be followed in specific cases where, say, the design space of visualization tasks described in Schulz et al. (Schulz et al., 2013) was created with little regard for the details of the data manipulations required to ultimately produce the visualization.

While the objective of this work is to seek a mathematical structure to support the visualization of simple differences between many numbers, the calculations of their significance is, in fact, necessarily complex. That is, the complexity derives from the need for an intuitive visualization.

The article is organized as follows: Section 2 (Methods) describes the mathematical underpinnings of the visualization. Section 3 (Data) describes the data that will be simulated to demonstrate the methodology. Section 4 (Results and Discussion) presents a discussion of results. Section 5 (Conclusion) contains the conclusions.

2. METHODS

In this section, we will describe in detail how the Bayesian approach can provide the desired representations and how the query results will be presented. The calculations described below are implemented within a Perl script available at http://sourceforge.net/projects/databasequalitymanagement. Detailed documentation of the source code and mathematics can be found in the same location.

2.1 BAYESIAN FORMALISM

The Bayesian formalism allows one to calculate, intuitively and concisely, the two similarity measures previously discussed: The first quantifies the probability that, within statistical uncertainties, the fractional patient frequencies (PFs) among the hospitals are consistent with the fractional PFs in the base pools (BPs). The second is the probability that the encounter-to-patient ratios (EPRs) are similar across all hospitals. Within the Bayesian formalism, there are no statistical tests or tests of significance. The probability is simply the probability or belief that the distributions or ratios would be the same were it not for statistical fluctuations. The probability calculated requires no statistics expertise: it is as intuitive as the probability of rain showers in a weather forecast. Details of the mathematical framework follow.

2.1.1 PF Similarity

Hospital similarity in Patient Frequency (PF) is defined by the relative size of their Base Pools (BP). For instance, suppose that a query returned the PFs of 91, 81, and 220 for three hospitals, CCHMC, CHCO, and CHOP, respectively. Suppose further that the corresponding BPs were 1,000, 2,000 and 3,000 patients, respectively. We wish to quantify whether there is a statistically significant difference between the PF ratios 91:81:220 and BP ratios 1,000:2,000:3,000. That is, we want to know if we were to somehow replicate these three hospitals infinitely many times, what is the probability that the distribution of counts averaged over all the replications would be 1,000:2,000:3,000? In this context, "different" can mean either all but one hospital are consistent with the BP ratio, or all hospitals are inconsistent with the BP ratio.

Formally, the (posterior) probability that the PFs are similar is calculated using Bayes' theorem, which is the key equation in the Bayesian formalism:

$$P(\text{same}|\ \vec{Q}) = \frac{P(\vec{Q}|\text{s ame})P(\text{same})}{P(\vec{Q}|\text{s ame})P(\text{same}) + \sum_i P(\vec{Q}|\text{i}^{\text{th}}\ \text{hosp is diff})P(\text{i}^{\text{th}}\ \text{hosp is diff}) + P(\vec{Q}|\text{a ll diff})P(\text{all diff})}$$

where, generally, $P(\vec{Q}|X)$ is a likelihood and $P(X)$ is a prior, which are discussed in more detail below. The likelihood encapsulates the probability of obtaining the observed outcome, $\vec{Q}$, given the "same" or "different" hypothesis. For instance, the χ^2 statistic is directly proportional to the likelihood. The priors encapsulate knowledge or assumptions about the hypotheses before $\vec{Q}$ is measured. If no assumptions are made (for example, if this is the first-ever observation of anything like $\vec{Q}$), then the priors related to the "same" and "different" hypotheses are set equal to one another.

$P(\vec{Q}|\text{same})$ is the likelihood of obtaining a set of PFs, $\vec{Q}$, with the assumption they are similar. This term takes the form of a multinomial distribution where the probabilities are set according to the relative sizes of the BPs. The counts in the multinomial distribution are the PFs from the query.

$P(\vec{Q}|\text{all diff})$ is the likelihood of obtaining the PFs given the distribution of PFs is different from the distribution of PFs in the BP. Quantitatively, the hypothesis is that the PFs are not accurately determined by the BPs, and so every distribution is equally probable. Therefore, this probability also takes the form of a multinomial distribution, except the multinomial probabilities are summed over (integrated).

$P(\vec{Q}|\text{i}^{\text{th}}\ \text{hosp diff})$ is similar in form to $P(\vec{Q}|\text{all diff})$, with the added constraint that all the hospitals except the ith hospital must be consistent with the BP PF distribution.

$P(\text{same})$ is the prior probability or expectation that all the hospitals are similar. Since we assume a priori that it is equally probable that the hospitals

for a particular query are the same, then $P(\text{same}) = 1/2$.

$P(\text{all diff})$ and $P(\text{i}^{\text{th}}\ \text{hosp diff})$ $P(\text{all diff})$ is the prior probability or expectation that all the hospitals are different. $P(\text{i}^{\text{th}}\ \text{hosp diff})$ is the prior probability or expectation that all but one of the hospitals is the same. It is assumed a priori that the probability that the hospitals are different in some way is 1/2 and that it is equally probable for all the hospitals to be different or for the ith hospital to be different. Therefore, for $N_{\text{hospitals}}$ hospitals, $\text{P(all diff)} = \text{P(ith hosp is diff)} = 0.5/(N_{hospitals} + 1)$.

The Bayesian formalism empowers the formation of the limited number of conceptual categories above which in turn provide the visualization with a limited number of conceptual categories relevant to the questions of interest: are hospitals the same or different; are all hospitals different or just one; is any difference higher or lower? These are the questions the visualization seeks to answer and which the statistical framework provides.

2.1.2 EPR Similarity

Encounter-to-patient-ratio (EPR) similarity is quantified by the probability that, within statistical uncertainties, the EPRs of the three hospitals are the same. For instance, suppose a query produced EPRs 5:1, 6:1 and 8:1 for the three hospitals under consideration. The probability that they are similar is the probability that the differences are due only to statistical fluctuations. That is, if we were to somehow replicate these three hospitals many times, it is the probability that the EPRs averaged over all the replications would be the same.

To calculate the EPR similarity, we again calculate Eqn. 1 but with terms that have an entirely different meaning. The idea behind the calculation is to express the patient and encounter counts as if they were binomially distributed, with the constraint that the probability of an "encounter" is always more than that of a "patient". This constraint follows from the fact that there are always at least as many encounters as patients. The Bayesian formalism allows this assumption to be neatly folded into the calculation of the final (posterior) probability in Eqn. 1. We then determine the probability that the relative probability of a "patient" versus an "encounter" for all the hospitals is the same.

A detailed description of each term follows.

$P(\vec{Q} \mid \text{same})$ is the probability that, within statistical fluctuations, the EPRs of the hospitals ($\vec{Q}$) are the same. Mathematically, $P(\vec{Q} \mid \text{same})$ is a product of binomial distributions which are integrated under this hypothesis and under the constraint that the chance of an encounter must be larger than that of a patient, hereafter called the EPR constraint.

$P(\vec{Q} \mid \text{all diff})$ is the probability that, beyond statistical fluctuations, the EPRs of the hospitals are different. Again, this term is a product of binomial

distributions which are integrated individually under the EPR constraint.

$P(\vec{Q} \mid \text{i}^{\text{th}} \text{ hosp diff})$ is the probability that, within statistical fluctuations, the EPRs of all but the ith hospital are the same under the EPR constraint. Again, this term is a product of binomial distributions which are integrated individually under this constraint.

$P(\text{same})$, $P(\text{all diff})$, and $P(\text{i}^{\text{th}} \text{ hosp diff})$ are probabilities that retain the same definitions as those in the previous section.

NOTE: both the PF and EPR similarity measures allow for the number of patients to be zero.

2.1.3 Determination of Outlying Hospitals, Excesses and Deficits

If the hospitals are different (i.e., $\text{P}(\vec{Q} \mid \text{same}) < \text{P}(\vec{Q} \mid \text{all diff})\text{P}(\text{all diff}) \cdot + \text{P}(\vec{Q} \mid \text{i}^{\text{th}} \text{ hosp is diff})\text{P}(\text{i}^{\text{th}} \text{ hosp is diff})$) then the visualization scheme requires that we determine how they are different. Specifically, we must determine if either (1) all the hospitals are different, or (2) all the hospitals are similar except one. This determination is made by comparing the probability that all the hospitals are different, $P(\vec{Q} \mid \text{all diff})$, to the probability that all the hospitals except for the ith one are similar. If it is more probable that a single hospital is different from the others (i.e., $\text{P}(\vec{Q} \mid \text{i}^{\text{th}} \text{ hosp is diff}) > \text{P}(\vec{Q} \mid \text{all diff})$) then the outlying hospital is found by determining that i which maximizes $P(\vec{Q} \mid \text{i}^{\text{th}} \text{ hosp diff})$.

If there exists an outlying hospital, all that remains is to determine whether or not the outlier is the result of an excess or deficit. This is performed with simple subtraction. If the outlying PF is the result of an excess (deficit), its fractional PF will be larger (smaller) than the fractional PFs in the other BPs. Meanwhile, if the outlying EPR is the result of an excess (deficit), it will simply be larger (smaller) than the other EPRs. Visualization-wise, the corresponding up or down arrow colors are matched to the color in columns 2 or 3 in Figure 1a, depending on whether the outlying deviation is in PF or EPR respectively.

2.2 VISUALIZATION

The purpose of the visualization scheme is to provide a way to efficiently determine whether or not the PFs or EPRs from different hospitals differ, and, if so, how. The Bayesian formalism supplies the results in categories. To concisely and intuitively visualize these categorical results, we choose a tabulated format, shown in Figures 1a and 1b, which show two possible visualizations. Fig. 1a will be the focus of this work, while Figure 1b demonstrates an alternative representation of essentially the same information.

In Figure 1a, each row represents an independent query. The columns are discussed in turn. The far left column shows the fact to be queried, although in the simulated case presented here the queries are simply denoted Query 1, Query 2, etc. The cells in the next two columns display six boxes; the number of filled boxes is proportional to the inter-hospital similarities of the PFs and EPRs respectively. Six boxes are chosen based on the need for an even number of boxes (to discern a probability over/under 50%) while maximizing the number of boxes than can be quickly enumerated.[2] Quickly discerning differences in the probabilities across the diagrams was the main concern when determining how the probability would be represented. A horizontal row of boxes offered an intuitive way to visually measure difference quantity rather than a single continuous bar.

2 Six objects can be enumerated in about 1 second (Trick and Pylyshyn, 1994).

The visualization of the probability is reinforced by the color of the filled boxes. The boxes are colored green if the probability of similarity is between 50% and 100%, yellow if it is between 5% and 50%, and red if it is below 5%. Hovering the cursor over the boxes within these columns reveals a call-out with the precise probability that the PFs or EPRs are similar, as demonstrated in Query 4 with the black arrow cursor. The remaining columns contain the PFs and EPRs for each hospital, where each PF cell contains both the PF as well as the corresponding percentage of patients this number represents from the BP. (This percentage is useful in determining whether statistically significance differences are, in fact, important.)

In the case where all but one of the PFs or EPRs are similar, an up or down arrow indicates an excess or deficit, respectively, in the "outlying" hospital. The colors of the cells with these arrows match the color of the corresponding second or third row. For instance, row 2 shows a statistically significant excess in CHOP's PF, which is indicated with an upward-pointing arrow and a yellow cell which is matched to the yellow PF cell in column 2. In the case where all the PFs or EPRs are different from each other, bi-directional arrows fill all three cells, which are color-matched to columns 2 or 3, respectively.

It is worth emphasizing that the colors mostly serve to reinforce what is visualized in other ways. As each cell in columns 2 and 3 has at least 1 box filled, the minimum discernible probability from the visualization for a color-blind investigator would be 16%, in contrast to 5% for one who is able to differentiate red from yellow. Regardless, a precise probability can always be found by scrolling over the cell in column 2 or 3.

However, if it is less important to visualize the degree of similarity than it is to identify differences, an alternative representation like the one in Figure 1b may suffice. In this visualization, differences are simply indicated by red cells, and the degree of similarity is indicated by the number of arrows. Two arrows (on top of one another) indicate a probability of similarity less than 5%, and one arrow indicates a probability of similarity between 5% and 50%. If the PF (EPR) cell is white, the number or ratio is assumed to be consistent with the BP (other ratios). A precise probability of

similarity can still be found by scrolling over any red cell, as indicated by the cell in Query 2. However, our discussion below will focus on the visualization in Figure 1a.

Regardless, the following information must be visualized for a particular query:

1. Whether or not the distribution of PFs across the hospitals is significantly different from the distribution of PFs in the BPs,
2. Whether or not differences in the EPRs are statistically significant,
3. If there are differences between the hospitals, whether all the hospitals are different from one another, or all but one of the hospitals are similar,
4. If all but one of the hospitals are similar, which one is the outlying hospital,
5. Whether an outlying hospital contains an excess or deficit,
6. A visual representation of the similarity measure for PFs and EPRs.

3. DATA

The visualization is demonstrated with simulated queries that are nearly identical to ongoing queries of epilepsy databases at CCHMC, CHOP, and CHCO. The only differences between the simulated and actual queries are the values of the PFs and EPRs; the visualizations and magnitudes of the PFs and EPRs are the same.

We "simulate" 7 database queries of epilepsy patients from three hospitals. The query results are characterized by well-defined inter-hospital variabilities, which are discussed in turn.

Query 1

The PF distribution across the hospitals is the same as the distribution of BP PFs, and the EPRs are the same for all the hospitals.

Query 2

The EPRs are the same for all hospitals. The PF distribution is the same as the BP PF distribution, with the exception of one hospital (CHOP), which has a 100% excess in PF.

Query 3

The EPRs are the same for all hospitals. The PF distribution is the same as the BP PF distribution, with the exception of one hospital (CHOP), which has a 95% deficit in PF.

Query 4

The PF distribution across hospitals is the same as the distribution of BP PFs. The EPRs are the same for all hospitals except one, which has a 100% excess in the EPR.

Query 5

The PF distribution across hospitals is the same as the distribution of BP PFs. The EPRs are the same for all hospitals except one, which has a 95% deficit in the EPR.

Query 6

The EPRs are all different, but the PF distribution across hospitals is the same as the BP PFs.

Query 7

The EPRs for all the hospitals are the same, but the PF distribution across hospitals is different from the BP PFs.

The number and ordering of the queries in Figure 1a make the diagram appear deceptively clean. The real data may contain hundreds of queries with seemingly randomly distributed probabilities. On the other hand, the diagram will be more ordered for real data from the clinical point of view, as the queries can be grouped according to type. For instance, all queries concerning anti-epileptic drugs can be grouped to help elucidate relations between (dis)similarities in patients and encounters.

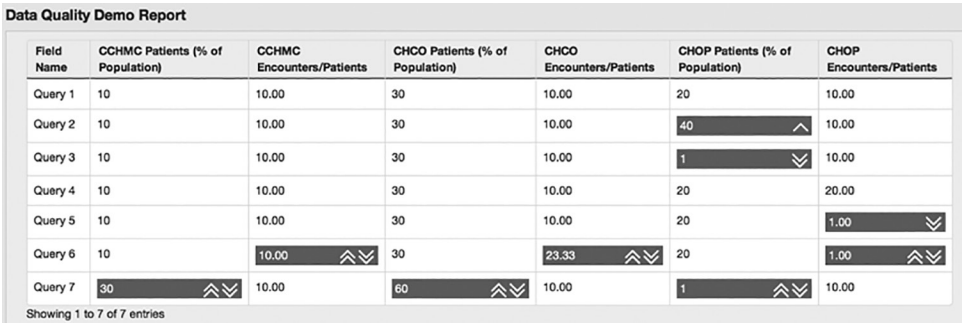
Data Quality Report

Field Name	Patient Freq Similarity	Encounters/Patients Similarity	CCHMC Patient Freq (% of Population)	CCHMC Encounters/Patients	CHCO Patient Freq (% of Population)	CHCO Encounters/Patients	CHOP Patient Freq (% of Population)	CHOP Encounters/Patients
Total Population	N/A		1000	3.00	3000	3.00	2000	3.00
Query 1			10 (1.0 %)	10.00	30 (1.0 %)	10.00	20 (1.0 %)	10.00
Query 2			10 (1.0 %)	10.00	30 (1.0 %)	10.00	40 (2.0 %) ↑	10.00
Query 3			10 (1.0 %)	10.00	30 (1.0 %)	10.00	1 (0.1 %) ↓	10.00
Query 4	0.57		10 (1.0 %)	10.00	30 (1.0 %)	10.00	20 (1.0 %)	20.00
Query 5			10 (1.0 %)	10.00	30 (1.0 %)	10.00	20 (1.0 %)	1.00 ↓
Query 6			10 (1.0 %)	10.00 ↕	30 (1.0 %)	23.33 ↕	20 (1.0 %)	1.00 ↕
Query 7			30 (3.0 %) ↕	10.00	60 (2.0 %) ↕	10.00	1 (0.1 %) ↕	10.00

Showing 1 to 8 of 8 entries

FIGURE 1A:

This visualization is the focus of this work. Each row represents an independent query. The far left column shows the fact to be queried, although in the simulated case presented here the queries are simply denoted Query 1, Query 2, etc. The cells in the next two columns display a series of boxes; the number of filled boxes is proportional to the inter-hospital similarities of the PFs and EPRs respectively. The visualization of the probability is reinforced by a common-sense color scheme for the filled boxes. The boxes are colored green if the probability of similarity is between 50% and 100%, yellow if it is between 5% and 50%, and red if it is below 5%. Hovering the cursor over the boxes within these columns reveals a call-out with the precise probability that the PFs or EPRs are similar, as demonstrated in Query 4 with the black arrow cursor. The remaining columns contain the PFs and EPRs for each hospital, where each PF cell contains both the PF as well as the corresponding percentage of patients this number represents from the BP. In the case where all but one of the PFs or EPRs are similar, an up or down arrow indicates an excess or deficit respectively in the "outlying" hospital. The colors of the cells with these arrows match the color of the corresponding second or third column.



Data Quality Demo Report

Field Name	CCHMC Patients (% of Population)	CCHMC Encounters/Patients	CHCO Patients (% of Population)	CHCO Encounters/Patients	CHOP Patients (% of Population)	CHOP Encounters/Patients
Query 1	10	10.00	30	10.00	20	10.00
Query 2	10	10.00	30	10.00	40	10.00
Query 3	10	10.00	30	10.00	1	10.00
Query 4	10	10.00	30	10.00	20	20.00
Query 5	10	10.00	30	10.00	20	1.00
Query 6	10	10.00	30	23.33	20	1.00
Query 7	30	10.00	60	10.00	1	10.00

Showing 1 to 7 of 7 entries

FIGURE 1B:

This visualization shows an alternative representation where differences are simply indicated by red cells. The degree of similarity is indicated by the number of arrows. Two arrows (on top of one another) indicate a probability of similarity less than 5%, and one arrow indicates a probability of similarity between 5% and 50%. If the PF (EPR) cell is white, the number or ratio is assumed to be consistent with the BP (other ratios). A precise prob¬ability of similarity can still be found by scrolling over any red cell, as indicated by the cell in Query 2.

4. RESULTS AND DISCUSSION

We demonstrate how the Bayesian formalism allows us to meet the visualization purpose described in Section 2.2, including the requirement for an intuitive representation of the degree of inter-hospital similarity. We also demonstrate that the representation of probabilities makes the results of the seven queries described in Section 3 quite clear.

We first discuss the relation between the probability visualization and variability of the PFs and EPRs for these queries, as well as the unqueried "Total Population" in Figure 1b, in turn.

Query 1

The green color codes in Columns 2 and 3 are exactly what we expect from a query that renders PF proportions that reflect the PF proportions in the BP. The probabilities of both the PFs and EPRs appear as green, with probabilities of similarity 97% and 91%, respectively.

Queries 2 and 3

The EPRs are the same while CHOP shows an excess and deficit in PFs relative to the BPs for the two queries. As expected, the EPR probabilities are color-rendered green for both queries. Also as expected, the PF probabilities for the two queries show low probabilities of similarity indicated by yellow and red, respectively. The former probability turns out to be substantially larger of the two (34% versus 0.06%). Although the magnitude of the deviations from maximum similarity in the CHOP queries are similar (a 20 count excess and a 19 count deficit), the differences in their standard deviations allow for disparate statistical fluctuations in the EPRs. For instance, the standard deviation in PF for Query 2 is ~6 counts, while the standard deviation in PF for Query 3 is only 1.

Queries 4 and 5

These queries show an excess and deficit in EPRs while fixing the proportion of PFs to those in the BPs. Query 5 gives the expected red box in column 3, while it is green for Query 4 with a 57% probability. However, the high probability for Query 4 arises from two factors that suggest that such a statistical fluctuation is possible. First, a statistical fluctuation in the numbers of patients and encounters that is smaller than one standard deviation brings the EPRs into agreement. Second, the number of hospitals is folded into the probabilities. For instance, the chance of finding a one-standard-deviation fluctuation is greater in three hospitals than in two. By contrast, the same agreement does not exist in Query 5.

Queries 6 and 7

These queries render different PFs and EPRs, and give the expected representations of similarity in columns 2 and 3.

Total Population

This row contains the PFs and EPRs for the BPs; it is the unqueried data set. Quantifying the similarity of patients for the BPs is uninteresting as their PFs define the gold standard for similarity when comparing inter-hospital PFs. An "N/A" is therefore inserted into the second column of this row. On the other hand, quantifying the similarity of the EPRs is crucial as differences in their values may reflect actual differences in data quality or care. Here the EPRs for the BPs are the same, which is supported by the high probability of similarity indicated by the green box in column 3. A method of comparing BP and query results to isolate inter-hospital differences is discussed in Section 5.

Note that although the probability visualizations are reinforced with a red-yellow-green color scheme, the colors are not critical for interpretation of results. This design decision for both Figures 1a and 1b arose from the fact that about 8 percent of males, and 0.5% of females, have some degree of congenital color deficiency (Deeb and Motulsky, 2012), which requires a careful consideration of color palettes when designing visualization schemes for representation of meaning, causality, and importance of query comparison.

5. CONCLUSIONS

We showed that the challenges of visualizing inter-hospital similarities and differences in patient database queries can be met by choosing the appropriate formalism to quantify them. In so doing, we demonstrated the potentially symbiotic relationship between statistics and visualization. The chosen (Bayesian) formalism allowed us to compute concise and intuitive similarity measures that fit well into the desired visualization scheme. The ability of our formalism to include many factors, such as statistical fluctuations and prior information, not only suggests the need for a direct calculation of the probability of similarity, but also hints at how the probability measure

compliments the visualization procedure. That is, a visual/mathematical formalism shown here goes beyond simply flagging numbers that fall within categories with arbitrarily set limits. Also, the measures of similarity used within the visualization scheme described here do not require any statistics expertise for interpreting them. Further, the formalism is extremely flexible and even allows the computation of similarity measures when no patients are found in one or all the hospitals. These measures are implemented within publically available software package. The software along with detailed documentation of the source code and mathematical framework can be found at http://sourceforge.net/projects/databasequalitymanagement.

However, the formalism does contain a number of subtle approximations. For instance, the binomial and multinomial distributions technically allow for the number of patients to be greater than the number of encounters. One can certainly introduce additional constraints to prevent this unphysical situation, but the mathematics then becomes non-analytic.

It must also be argued that some of the test queries yielded rather non-intuitive results (seemingly questionable representations); however, they were shown to be reasonable when it was revealed that statistical fluctuations and the number of inter-hospital comparisons were factored into the measure of similarity.

Sophisticated analyses to isolate the sources of inter-hospital differences becomes possible with the presented formalism. For instance, if the EPRs for the BPs are different but the PFs and EPRs for a query are the same, then the query's "fact" is unlikely to be the source of the EPR differences in the BPs. Isolating differences is further facilitated by the ability to point to outlying hospitals that cause differences in PFs and EPRs.

Visualization allows for these and similar analyses to be performed on a large scale over many queries and many similarity measures. With this in mind, there remain many possible extensions to the query comparisons presented in this work. For instance, comparing EPRs was important to understanding possible differences in care or reporting of care. However, various factors may contribute to inter-hospital variability in the number of clinical notes for a given procedure. These inter-hospital similarities and differences can be explored by comparing "encounters":"clinical notes":"patient frequencies" ratios and by changing the binomial distributions in Section 2.1.2 into tri-nomial distributions. Adding similarity measures, as well as increasing the sample size via bringing in additional hospitals, will result in a larger diagram. Such a diagram will be more challenging to design and display in an easily readable manner.

Analysis could also be facilitated by ordering the queries. For instance, it can be imagined that ordering by degree of inter-hospital dissimilarity would facilitate the identification of "problematic" queries. However, differences in data quality and care are easier to identify if

the queries are grouped by, say, types of drug refills or diagnostic tests.

Better, the queries could be ordered by relevance using a survey strategy similar to the one described in (Pestian et al., 2013) where cluster analysis was combined with expert opinion to identify subject matter "groups" and weight those groups by importance. Regardless, tracing the sources of differences could be facilitated by providing a button that would enable one to bounce between various ordering schemes.

The identification of important differences will be facilitated through clinical expertise; while certain differences in values may be statistically significant, they may not be important. The Bayesian formalism, in fact, allows one to fold in such allowable ranges by imposing a range of allowable proportions. This range is folded into the probability (specifically, $P(\vec{Q} \mid \text{same})$) by integrating over that range.

The number of hospitals can also be varied by changing the order of the multinomial distribution in the PF comparisons, as well as the number of binomial distributions in the EPR comparisons. Further, PFs and EPRs can be allowed to differ beyond statistical fluctuations

The more profound problem of the so-called "look elsewhere effect" should also be folded into the calculations/visualizations. This problem arises when, over many queries, the inevitable occasional large statistical fluctuation is misinterpreted as a significant deviation. This problem is solved in the classical (frequentist) approach by imposing corrections on p-values (for example, Aickin and Gensler, 1996). However, the Bayesian approach allows one to naturally normalize the probabilities to account for multiple queries. Regardless of the statistical approach, folding this effect within the similarity measures serves to compliment the visualization scheme by preventing chance fluctuations in the data from appearing as statistically significant differences and thereby preventing false findings.

ACKNOWLEDGEMENTS

The authors would like to thank the three anonymous reviewers for their valuable comments and suggestions, which improved the quality of the paper.

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Book Review:

Design for information, an introduction to the histories, theories, and best practices behind effective information visualizations.

by

Isabel Meirelles

Beverly, MA: Rockport Publishers, 2013.

Jorge Frascara

Design for information is a thorough representation of both the field of information visualization and the research interests of the author, whose focus is on "the theoretical and experimental examination of the fundamentals underlying how information is structured, represented and communicated in different media."

Beginning with the "big picture," the book includes an amazing collection of examples, the most thorough I have seen to date in a volume. The author organizes the content according to several categories represented by the titles of the chapters: 1. Hierarchical structures: trees; 2. Relational structures: networks; 3. Temporal structures: timelines and flows; 4. Spatial structures: maps; 5. Spatio-temporal structures; and 6) Textual structures. An appendix, notes, a bibliography, a contributors list, and an index complete the content of the book.

Design for information is an extensive taxonomy of data visualization types and is "a must" for anybody interested in the work done in the area. Each one of the hundreds of examples is explained and discussed, forming a kind of encyclopedia on the subject. It seems that nothing escaped the exemplary collection that Meirelles assembled. The discussions and explanations normally focus on what information is represented and how it is represented.

It is interesting to see, as well, how many different professional fields today use diagrams to organize and represent information: basic science, applied science, education, engineering, medicine, and technologies, etc. The value of the book is centered on the inclusion of examples of how many different problems are now being addressed through data visualizations, how many historical efforts preceded whatsoever is

done today, and how the advent of the computers have allowed the field to explode by handling large data sets as well as dynamic representations.

At the end of the examination of the 224-page volume I became curious as to how these diagrams might have performed with the users they were intended for in terms of ease of comprehension; what conclusions I could arrive at from an evaluation of the examples from a perceptual and cognitive human factors perspective; or how a complementary book could contribute to the development of best practices. I would not expect that one volume could be so extensive as this one and also cover the field critically. However, I have to wonder how the super-complex visualizations permitted by computer programs today would perform regarding comprehension, memorization, and use of the information presented. The discussion on perception and cognition is very brief, and it might leave some readers wondering about the assertions made: they are proposed as principles without them being discussed. This topic, as well as Gestalt theory, are not considered during the description of examples. The size of some reproductions is too small to assess their quality as data visualizations. They appear as examples of problems addressed but not as information in themselves. To compensate for this, the book includes valuable URLs for people interested in seeing in better detail many of the diagrams shown.

While the above issues could be perceived as weaknesses, the strength of the book is its truly amazing array of examples and the rare historical diagrams it offers. It also displays an uncommon erudition and includes an extensive and useful bibliography. I do not know how long Meirelles took to complete the manuscript, but it feels like a lifetime project. These assets, coupled by excellent production, make this an indispensable publication for anyone interested in information visualization.

Book Review:

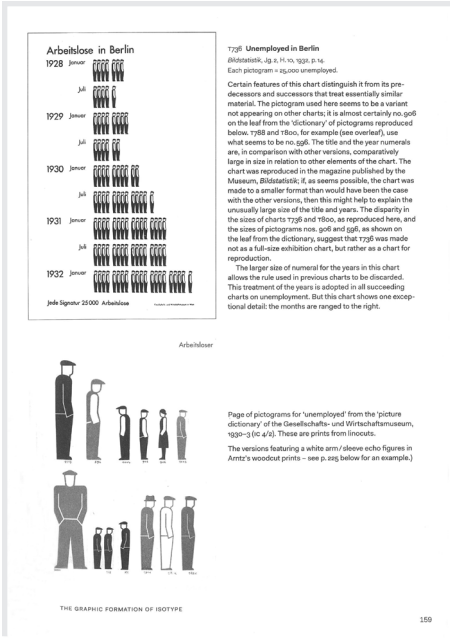
Isotype: Design and contexts 1925–1971

by

Burke, Christoher; Kindel, Eric; Walker, Sue (Eds.)

Hyphen Press, London, 2013

Per Molleup



Page 158
Males with flat cap and hands in pocket stereotype unemployed persons. Striking workers have crossed arms.

Isotype, why not?

The term Isotype, an acronym for International System Of TYpographic Picture Education, is a technique of data visualization introduced by sociologist, economist, and philosopher Otto Neurath. Originally called "The Vienna School of Pictorial Statistics" and developed and practiced at the Gesellschafts- und Wirtschaftsmuseum in Wien (Social and Economic Museum of Vienna), 1925-34, Isotype's purpose was to communicate societal information to visitors. In 1935, Neurath's technique was renamed, and Isotype began its own life and was used for other purposes in other places.

Isotype builds on the idea expressed in Neurath's often-repeated adage, "To remember simplified pictures is better than to forget accurate numbers" (p. 85). Therefore, Isotype is best known for Picture tables—graphic displays with rows of repeated pictograms each standing for a number of real world units. The picture tables embody the proposition that it is easier to compare quantities by comparing numbers of well-presented symbols, than to compare symbols of different size. Pictograms in the Isotype picture tables are scaled: in a display showing unemployment, each pictogram would stand for 1,000; 100,000; or 1 million – or another round number of unemployed persons. In picture tables, the reader must count the pictograms in different groups and multiply with the scaling factor to get the total amounts. The number of the repeated pictograms in a picture table is most often rounded off. Some Isotype picture tables feature half, quarter, or smaller fractions of pictograms. Even then, Isotype displays are typically not as precise as the numbers they represent.

Isotype: Design and contexts 1925-1971 describes Isotype in a period delimited by 1925 when the Gesellschafts-und Wirtschaftsmuseum in Wien was founded and 1971 when the Isotype Institute in London closed. The book comprises 12 chapters dealing with the genesis and further development and design of Isotype. The book includes two kinds of information; it describes Isotype design principles, and it describes the process by which Isotype was developed and disseminated. To this reviewer the former part is the most interesting, while the latter part serves as a useful historical backdrop.

TEACHING MUSEUM

In the first of two central chapters, Christopher Burke covers the ten-year lifetime of The Gesellschafts-und Wirtschaftsmuseum in Wien including the formative years of Isotype. The idea behind Isotype predated the museum. Otto Neurath, sociologist, economist, and philosopher, had already applied charts with pictorial descriptions of quantities for the Museum für Siedlung und Städtebau, Museum for Settlement and Town Planning. Eager to educate by means of these didactic tools, Otto Neurath suggested a new museum to expand the ordinary population's understanding of national and world relations. The social democrat regime in Vienna understood the importance of education and provided the necessary financial support.

Otto Neurath invented Isotype, but more than that, he promoted it. Philosophically and organisationally trained in addition to being well connected academically and politically he spread the word and established the connections that were vital to the incubation of a new idea like Isotype. Neurath partnered his strong interest in education of ordinary people with his equally strong social commitment resulting in his belief that progress depends on knowledge, and knowledge should be delivered in ways that are both attractive and memorable – essential qualities of Isotype.

The Gesellschafts und Wirtshaftsmuseum in Wien was not a museum in the traditional sense of that word; and therefore consistent with Neurath's view that "The modern museum should be a teaching museum, a means of education, a schoolbook on a grand scale…" (p. 30). The Gesellschafts and Wirtshaftsmuseum in Wien consisted primarily of graphic charts explaining societal matters, first and foremost quantities. The museum introduced a number of advanced ideas to meet its audience. To accommodate prospective visitors the museum was open evenings and Sunday mornings. Also, the museum branched out at several places where visitors would be. At a certain time, the museum would exhibit at several different locations in Vienna including the town hall. A central corner shop museum open in the lunch hours had as many as two thousand visitors a day. At the corner shop special interactive knowledge machines were placed where visitors could test their knowledge – anticipating a distant, digital future. Exhibition material was reused and exchanged between permanent

and time limited exhibitions in several places. Along with its own exhibitions, the museum took part in fairs and exhibitions in Austria and abroad.

The museum also published books, pamphlets, and journals to reach its audience in time and space. *Gesellschaft und Wirtschaft*, Society and Economy, was a collection of 100 Isotype charts. *Fernunterricht*, distant teaching/learning, later renamed *Bildstatistik*, Pictorial Statistics, prefigured modern distance learning.

Three persons led the development of Isotype: Otto Neurath, a sociologist, economist, and philosopher; Marie Reidemeister, a German academic; Georg Arntz, a German graphic designer.

Austrian Otto Neurath's past career included his initiative to, and directorship of, the German museum of war economy in Leipzig during WWI. After the war, his presidency of the Central Office of Economics, in the Bavarian Soviet Republic, was followed by a conviction of assisting high treason and an eighteen-month, later suspended, prison sentence. In 1920, Neurath was back in Vienna to become the director of the Forschungsinstitut für Gemeindewirtschaft, Research Institute for Co-operative Economy. In this capacity Neurath initiated a Museum for Settlement and Town Planning, which within a year – also on Neuraths initiative – was replaced by The Gesellschafts-und Wirtschaftsmuseum in Wien.

Marie Reidemeister (after 1940 Marie Neurath) met Otto Neurath before the start of the Gesellschafts- und Wirtschafts Museum in Wien, became his right hand, and continued working with Isotype after Otto Neurath's death in 1945. Most importantly, Marie Reidemeister played and developed the role of 'transformer'. Otto Neurath and Marie Reidemeister considered the 'transformation' of a message into a principle for a graphic chart the crucial part of the work with Isotype. Transformation was the link between science and graphic design. According to Marie Reidemeister: "We think out which is the point that has to be brought home, and then we try to do so in such a way that everybody will grasp it. We avoid distracting the attention from the more important issues." (p. 15). Also according to Marie Reidemeister, other designers impressed by Isotype would emulate the form but hardly master the transformation (p. 14). Today, the term 'transforming' is not used, but the substance is a natural part of the work of information designers engaged in data visualisation in news media and elsewhere.

Georg Arntz was a German artist working with woodcuts in precise graphic shapes, which caught the attention of Otto Neurath. Georg Arntz began working for the museum in 1928 and in 1929 moved to Vienna where he developed the schematic graphic form that became a signature quality of Isotype. In the process he also changed the technical production from paper cuts to printing from linocuts.

Three conditions for launching Isotype were present. First, a strong-minded initiator with a firm social and educational commitment who was well connected politically; second, highly qualified principal collaborators; and third, a friendly political market.

Partly inspired by the political winds and the following possible need for a foothold outside Austria, Otto Neurath established in 1932 the affiliate Mundaneum to take care of international relations. In 1932 and 1933, Mundaneum established branches in Amsterdam and London respectively. In 1934, the International Foundation for the Promotion of the Vienna Method of Visual Education was established in The Hague. Later in 1934, when the political situation in Austria and Vienna as envisioned by Neurath became dangerous, he, his wife Marie Reidemeister, Georg Arntz, and two other collaborators moved to the Netherlands. The Gesellshafts- und Wirtschaftsmuseum was closed. Part of its material was already transferred to Mundaneum. The rest was seized by the new regime, not the first time a design initiative has been subject to political change. In 1940 the Neuraths moved on to England.

THE NETHERLANDS

Two chapters of the book deal with the continuous work in the Netherlands and England. In Vienna, Isotype had been a means to inform the visitors of the Gesellschafts- und Wirtschaftsmuseum. In the Netherlands the Neurath team had to earn their way from projects. Otto Neurath wrote two books in Basic English: *International Picture Language* and *Basic by Isotype*. Other jobs included production of a children's theatre puppet show and an art exhibition, *Rondon Rembrant*. Also, commissions resulted from Otto Neurath's frequent travels to the USA.

ENGLAND

When Germany occupied the Netherlands the Neuraths moved on to England, where Otto Neurath had been promised a teaching position at Oxford. The Isotype Institute was then established in 1942. The Isotype work in England followed two lines. The Neuraths wrote and designed a number of books for Adprint, a book packager who also published, and they worked on informative films together with British film producer John Rotha. The books dealt with the war effort and social policy. Apart from a couple of booklets this work included a three book series: *America and Britain*, *The Soviets and ourselves*, and *New Democracy*. Two chapters in *Isotype: Design and contexts 1925-1971* deal with film work and children's books respectively.

FILM

Documentary filmmaker John Rotha approached the Neuraths soon after their arrival in England to initiate a collaboration concerning films for the Ministry of Information. The first film, *A few ounces a day* about saving waste to be used in the war effort, was based exclusively on animated Isotype graphics. The Neuraths acted as de facto directors and Maria Neurath made a complete storyboard as well as the graphics to be animated. Later followed several films, where Isotype animations were combined with live action. A series of films that had significant results included, *Worker and*

warfront, which was shown for workers in factory canteens, *World of Plenty* and *Land of promise* which dealt with food and with planning respectively.

In 1945 Rotha established a special company, Unifilm, with himself and Otto Neurath as directors. After Otto Neurath's death Marie Neurath would continue the cooperation with John Rotha until 1948, when Unifilm closed down. In 1954 Marie Neurath contributed to a TV series, *The World is ours*, and in 1965 to a film *The physics and chemistry of water*.

The film work was not without problems. Some critics found that serious matters should not be treated through the genre of animation. The Neuraths complained when they did not have full control of the work, and Paul Rotha did not always find the necessary support for Isotype work from the Ministry. Professional designers recognise these kinds of problems. Otto Neurath also had some didactic reservations. Isotype on paper lets the viewer see and compare several displays concurrently in space, while film – working in time – doesn't provide that possibility. Also paper media, in contrast to film, gives viewers as much time as they want. Today video technology has solved this problem.

CHILDREN'S BOOKS

In her chapter about children's books Sue Walker rightly states that "The children's books produced by the Isotype Institute provide an excellent insight into Marie Neurath's work as a transformer and show that she had a particular skill in making charts and illustrations that were accessible to children of all ages." (p. 391). This chapter reaches beyond children's books: The account of Marie Neurath's approach is relevant to all designers concerned with data visualisation.

The children's book production took place from the 1940s into the 1970s. Otto Neurath took the initiative, but after his death Marie Neurath edited, wrote, and designed a large number of children's educational books, some of which were schoolbooks. Children's book series included *If you could see inside*, *I'll show you how it happens*, *Visual history of mankind*, *Visual science*, *Wonders of the Modern world*, and *Wonder world of nature*. The Isotype institute delivered both the text and design for these books. Illustrations would include pictograms and all kinds of explanatory drawings. In another series, *They lived like this*, the majority of the illustrations were drawings of contemporary artefacts. This series was co-written by external artists.

Marie Neurath's thoughts about the work with children's books are interesting to everyone working with data visualisation:

> I had to ask myself: what are the essential things we want to show, how can we use comparison, direct the attention, through the arrangement and use of colour, to bring out the most important things at the first glance, and additional features on closer scrutiny. Details had to be meaningful, everything in the picture had to be useful for information. (p.395)

From a note addressed to the readers of the second book in the Visual history series:

> Everything which would not help you understand the meaning, or which would confuse you, is left out. Colours are used only to help make the meaning clearer, never simply as decoration. This means that every line and every colour in these pictures has something to tell you. (p. 403)

USA

Three factors obstructed Isotype's introduction into the USA. The timing was not good. It was the middle of the depression, there were several imitators (just competitors?) around, and there was Rudolf Modley, a former part-time employee in the administration of the Gesellschafts- und Wirtschaftsmuseum in Wien. Rudolf Modley would cooperate and compete with the Isotype team in Den Hague and Oxford, and challenge Otto Neurath's views.

A group of influential supporters worked together to get Otto Neurath and Isotype to the USA. When in 1930 there was an opportunity to use Isotype at the Museum of Science and Industry in Chicago, Otto Neurath recommended the employment of Rudolf Modley. Here and later Modley acted more independently than envisaged by Otto Neurath.

In 1934 the supporters founded the Organizing Committee for the Institute for Visual Education "to establish in the United States an organization which can develop and promote the graphic methods of presenting social and economic facts, which have been characterised by the Vienna Method as exemplified in the work of the Gesellschafts- und Wirtschaftsmuseum in Wien under the direction of Dr. Otto Neurath" (p. 307). When the organisation did not follow Modley's advice, he created his own company, Pictorial Statistics Inc. Otto Neurath and Rudolf Modley held differing views. Neurath wanted standardised pictograms designed centrally while Modely had a more relaxed view. Neurath explained:

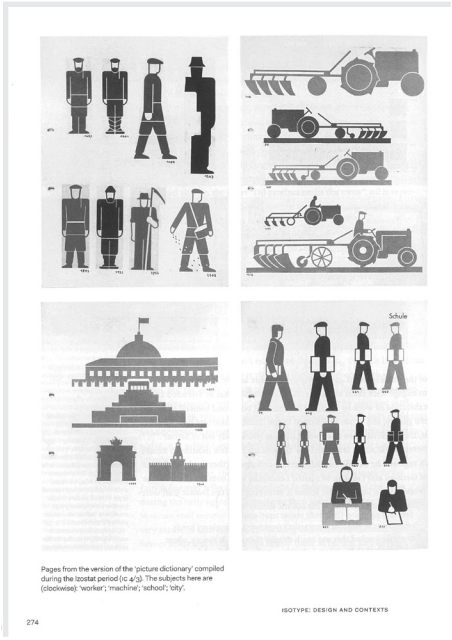
> That is to say, for our picture language one general list of a limited number of signs is needed for international use, and this has to be worked out by or under the control of one chief organization (This organization is now the ISOTYPE work-room at the Hague). (p. 332).

Also, Modley saw the pictograms as elements that could have their own life while Neurath saw pictograms as parts of visual arguments enabled by transformation. Modley was not interested in transformation. In line with this view he published symbols sheets with pictograms to be used by everyone and a book entitled, *1000 Pictorial Symbols* (1942).

Otto Neurath travelled to the USA several times and secured important commissions, primarily in the health sector. Isotype also delivered illustrations to *Compton's pictored encyclopedia* (1939) and Otto Neurath wrote *Modern man in the making* (1939) for Knopff publishers. After Neurath's death Marie Neurath wrote an essay on Isotype for Henry Dryfuss's *Symbol Source Book* (1972).

RUSSIA

The Isotype team's efforts in Russia took place from 1931-1934. Russia did not want to commission Isotype work from Vienna. Instead, they wanted Isotype staff to help establish a Soviet institute. A special organisation named Izostat was established with Otto Neurath as one of two directors, and several Isotype staff would join them for shorter or longer periods. The total staff at times would be as high as 75. A number of problems hindered cooperation. The work primarily dealt with visualising the established success of the first five-year plan 1928-1932 and the predicted success of second five-year plan 1933-1937. While The Vienna Method as practiced in Vienna was based on empirical facts, the Russians wanted forecasts to play an essential role. The estimates were often exaggerated. Another problem was that the Russians wanted naturalistic pictograms aligned with wanted Soviet realism. Also, the Russians wanted more, sometimes propagandistic, illustration. The cooperation resulted in some publications with more or less Viennese influence. Georg Arntz made a series of charts for Izvestia, charts for exhibitions, and a number of publications more or less influenced by the Isotype team. One Isotype idea was used with a new meaning. In the Vienna Method black was sometimes used to illustrate worse, while red would stand for better. In Russian charts red would stand for Russia while black would stand for other nations.



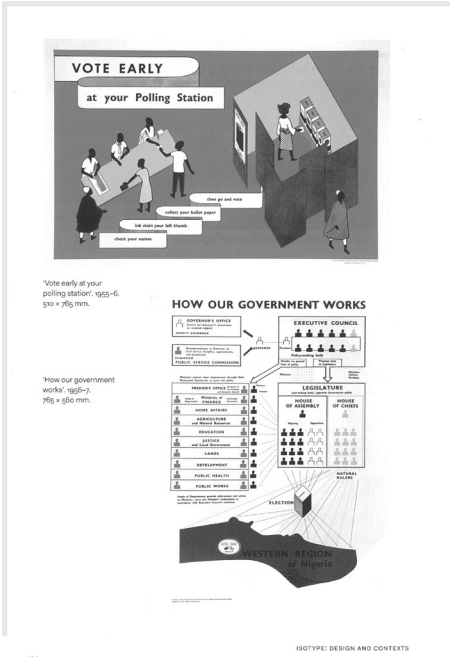
Page 174
Isotype work for Izostat in Moscow characterised by Russian realism.
(original in color)

In 1934 the Russians wrote to Otto Neurath that the contract did not comply with Russian law and the amount due at the end of the contract would not be paid. The latter incident was a major blow to the Isotype organisation, which in Den Hague depended on paid work. Izostat continued without Isotype help until 1940.

AFRICA

Some Isotype work in Africa took place from 1952-1958. Otto Neurath reportedly said that Isotype was not for the Viennese, but for the Africans (p. 449). In 1943 he worked on a proposal for an exhibition for the British Colonial Office entitled, *Human life in Africa*. This project did not materialize.

In 1953 a partnership between Buffalo Books, a subsidiary of Adprint, the Isotype Institute, and Purnell and Sons, a printing firm, planned and published the magazine *Forward* addressing the three British colonies Gold Coast (Ghana), Sierra Leone, and the Western Region of Nigeria soon to become independent. A trial issue and an issue number 1, dealing with culture, adventure, sports, and practical advice were published before the magazine was determined to be economically impossible in 1953.



'Vote early at your polling station', 1955–6. 510 × 765 mm.

'How our government works', 1956–7. 765 × 560 mm.

Page 480
Isotype work with limited abstraction for Western Region, Nigeria, promoted participation in an upcoming election. *(original in color)*

In 1954 Marie Neurath wrote a memorandum sketching what Isotype could do in the Western Region of Nigeria. It included a visual explanation of the aims of the government and the establishment of a local workshop for Isotype run by trained Nigerians. Marie Neurath visited Africa three times and a series of booklets and poster-leaflets were produced, while the workshop remained a plan.

For the Western Region a series of 16-page White Paper Booklets were published including *Education for all in the Western region*, *Better farming for better living in the Western Region*, *Health for all in the Western Region*, and *Paying for Progress in the Western Region*. Also a series of poster-leaflets dealing with health issues was produced. As indicated by the name, the poster-leaflets worked both as wall charts and as folded leaflets to take away. A following visit to the Western Region resulted in commissions for a new series of booklets.

Compared with the Western Region in Nigeria the Gold Coast and Sierra Leone had little work for Isotype. In 1956 Isotype made one leaflet for The Gold Coast, *The Volta River Project: what it means to you*, and in 1957 one for Sierra Leone *Voting, general election*.

In the late fifties the Isotype work in Africa came to an end. The chapter author, Eric Kindel, offers a number of probable explanations, one being the distance, another being the failure to establish a local workshop with trained local people. To the Isotype Institute the African experience meant realising the need for locally adapted symbols for man, woman, house, and more. The pictograms should 'speak'. In the same vein, charts were given familiar backgrounds. According to Marie Neurath: "[A]dherence to the method cannot go as far as imposing an alien background on those unable to share one's experience of it." (p. 495). This did not, according to Marie Neurath "imply that the system had to be radically changed" (p.495).

DESIGN

In the second central chapter of the book, Robin Kinross presents the design of Isotype. This chapter was originally a part of Kinross's MPhil thesis from 1979. (Robin Kinross is the owner of Hyphen Press, the publisher of this book as well as Otto Neurath's 'visual biography': *From hieroglyphics to Isotype* (2010) and a string of well presented books on typography.) The provenance of the chapter may explain the order in which it deals with the subject. The description begins with the formats of the wall charts, and moves through

colour, male and female, qualifying symbols, and guide pictures, down to pictograms and configuration. In the latter part Kinross codifies six types of displays dealt with by Isotype. This would have been a natural start of the chapter to be followed by pictograms. Apart from this peculiar arrangement the chapter gives a robust description of the elements used in Isotype. Kinross calls Isotype "a coherent approach to ordering material in graphic form" (p.107). It covers what we today call 'data visualisation'. In contrast to the remaining part of the book, Kinross offers a few critical remarks on Isotype.

Considering Neurath's interest in education it is remarkable that there exists no manual, no single, document explaining the Isotype design principles thoroughly. One reason could be that Isotype remained a work in progress. Another reason could be that Neurath did not want everyone to design visual displays, but rather to commission the displays from the initiators. So-called notes, single sheets each describing a design subject, were descriptive rather than prescriptive. They described current practice more than recommending what should be done. Also, Neurath's publication, *International Picture Language*, 1936, written in Basic English doesn't serve as a manual either.

Kinross's description of Isotype design gives a clear impression of Isotype being a work in progress. Pictograms, qualification, grouping of pictograms, use of colour, use of typography, and configuration would change considerably between 1925 and 1934, especially after Georg Arntz joined the team. However, this development did not always follow a straight line. Different principles were sometimes used concurrently; old design features were sometimes used after new design features were introduced. The development involved standardization, modularization, and simplification. Pictures would be reused and be combined; the use of colours would be restricted.

Kinross refers to the common misunderstanding that "quantified rows and columns" "might be typical of the work as a whole" (p. 142). Well, these picture tables and their pictograms are what most of us think about first when we think about Isotype. The picture tables and their pictograms are featured on the covers of publications and wherever Isotype is discussed. Kinross shows the width of Isotype by the following classification (p. 139).

Charts showing quantified material:

1. rows and columns [picture tables],
2. division of a whole (usually a checker-board),
3. geographically ordered pictograms and more diagrammatic charts,
4. quantities related to area (usually showing densities),
5. flows.

Charts showing non-quantified material:

Neurath broke down the picture table category into six sub-categories (p. 140):

1.1 comparison of total quantities,
1.2 where sizes of constituent parts are interesting, as well as total quantities,
1.3 where relative sizes of constituent parts are most important,
1.4 to make a shift particularly clear; alignment left and right to form an axis,
1.5 where the sizes of parts and of wholes are equally important; one compares both horizontally and vertically,
1.6 to allow comparison of parts and wholes, and to make a shift clear; especially important in showing changes over time.

A schematic drawing and an Isotype picture table illustrate each of these sub-categories.

While the fact that a large part of the text of this chapter is devoted to picture tables and pictograms may support the idea that Isotype first and foremost is picture tables, the book's numerous illustrations establish some balance. Isotype is both picture tables and a general approach to data visualisation.

In a chapter about pictograms, Christopher Burke confirms that a direct line from the Isotype pictograms to the pictograms used in transport and communication today hardly exists. However, qualities such as standardization, modularity, and schematization are parts of the Isotype heritage. Isotype pictograms worked in lines in picture tables to compare something, while modern pictograms in transport and communication simply point to the existence or condition of something. Otto Neurath, however, suggested that the Isotype pictograms could possibly also be used for public information signs. This application was not realised.

WHY NOT?

Isotype: Design and contexts 1925–1971 is a comprehensive introduction to the Isotype idea. The book's 12 chapters written by nine authors are well planned with a minimum of overlaps. While the main text goes into considerable historical detail, the illustrations present the elements and charts by which Isotype should be known and appreciated. The numerous illustrations – more than 400 – and their elaborate captions turn the book into a portable archive, which for everybody unable to access the Isotype collection at University of Reading will remain the most important Isotype resource.

Implicitly the book relays a well-known phenomenon: how a design idea born to solve one problem if successful becomes a

solution that looks for other problems. From informing the Viennese citizens the problem changed into finding potential outlets for the newfound method.

In the beginning of *Isotype: Design and contexts 1925–1971* Christopher Burke states, "The best way to bring these [the qualities of Isotype] to the fore is to examine it as a historical phenomenon in all the complexities of its contexts." (p. 14). This is questionable. To compare is the basic function of Isotype. Isotype should itself be compared with competing data visualizing formats. How can we evaluate the virtues of airships without comparing airships with other airborne vessels?

We still need a balanced discussion of the qualities of Isotype. What exactly is the Isotype approach? How does it survive today? How does Isotype compare with the display formats that news media and others prefer today? What are the pros and the cons of Isotype compared with other more frequently used data visualising formats such as bar charts, bubble charts, and line charts? Understandability, accuracy, attraction, and memorability are factors that should be discussed. The discussion should also include the intended target groups of Isotype and the contemporary audiences of news media and professional literature. Is Isotype only for uneducated people?

One probable finding is that most contemporary audiences prefer exact information to the visual explanation offered by Isotype picture tables. Today bar charts, pie charts, and bubble charts, which in principle present *visual* messages, are as a rule supplied with exact figures. Such displays are hybrids. They are half visual display, half table. The visual part lets the reader get a fast idea, while the figures deliver accuracy. In a short period Isotype's picture tables were also supplied with exact figures. In later displays the figures were abandoned. The big, undisputable advantage of isotype displays is that they are attention grabbing and attractive to look at. The visual attraction may be accompanied by good memorability.

P S

Design and contexts 1925-1971 is well crafted with a pleasing design. However, there are two minor flaws. First, the key to source abbreviations is located on page 18, while readers expect to find it in the beginning of the book where it would be easy to retrieve for later reference. Second, tiny, alphanumeric caption designations of up to four characters are written with lowercase numerals (6 and 8 with ascenders and 3, 4, 5, 7, and 9 with descenders), which are difficult to read, especially when presented in the very small type used for marginalia.

Per Mollerup
14 August 2014

THE MOST IMPORTANT DESIGN BOOKS MOST DESIGNERS HAVE NEVER READ:*

The Case for Mental Imagery

by

Stephen M. Kosslyn, William L. Thompson, and Giorgio Ganis

Mike Zender

date: 2035 CE
location: a design office

The designer looked at the screen and watched the child's memory of being sick. "I'm sorry to ask you this, but think of diarrhea again please," she said. The toilet shimmered into view briefly followed by transparent wavy lines. The designer noted the lines, then replayed the other children's memory and noted that 67% of them included shimmering, wavy lines to represent smell. "Thank you, that's all I needed. You've really helped me design this icon," she said.

Paul Rand once said that communication design is about "saying the commonplace in an uncommonplace way." (Rand, 1970, p. 36) This suggests that effective communication is essentially enhancing the familiar. For visual communication design, this means creating unique images that will connect in predictable ways with the images people already hold in their minds. From this perspective, the whole user-centered design movement is a cultivation of means for designers knowing, not just assuming, the mental images people have. Stephen Kosslyn, William L. Thompson, and Giorgio Ganis' book *The Case for Mental Imagery* (Kosslyn, Thompson, & Ganis, 2006, p. 4) gives designers an accurate glimpse into how mental images work.

MENTAL IMAGES

The plausibility of the fictional design office above hinges on the answer to a debate that has raged for at least decades, perhaps centuries: do we see mental images or not? According to Kosslyn, Thompson , and Ganis, "A mental image occurs when a representation of the type created during the initial stages of perception is present but the stimulus is not actually being perceived." Mental imagery is seeing what is not there, not an illusion or a mirage, but seeing in our mind something familiar and then perhaps using that mental image to think with or solve a problem. We might experience this by answering this question: how many windows face the street in your house or apartment? Given this task most people gaze blankly for a second

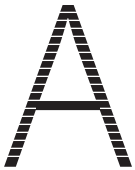
or two as they push into memory an image of their house and then briefly count the windows in the image. Kosslyn et. al. cite similar questions such as "Do you know which is darker green, a frozen pea or a pine tree? Or the hand in which the Statue of Liberty holds the torch" as examples where people use mental imagery.

Belief that this phenomena exists are not new. The authors briefly note that thinkers from the classic Greeks to Einstein claimed to use mental images "in memory, problem solving, creativity, emotion, and language comprehension." However, introspective experiences are notoriously difficult to study, easy to refute, and thus ripe territory for endless debate. Kosslyn, Thompson, and Ganis use Chapters 2 and 3 to detail the debate, Chapter 4 to marshal empirical findings from a broad range of cognitive psychologists and neuroscientists in order to settle the debate, and Chapter 5 to articulate a well-founded theory of mental imagery.

The theory articulated in the book is based on the process of visual perception which it describes. The eye is just the start of a process that occupies much of the brain. In fact, approximately 50% of the cerebral cortex is devoted to visual processing. The brain is not like a general-purpose computer with generic processing capacity to which are downloaded different problems for analysis. Rather, the brain is like a special purpose device with different neurons in different regions hard-wired to accomplish specific tasks. Vision is one of the brain's largest tasks. In visual perception a huge volume of sensations are processed and reduced to simpler more organized forms. It's as if individual camera pixels are processed for simple features then structured into units that correspond to distinct objects and key properties that define and distinguish those objects from each other. Kosslyn and his colleagues propose that we can reverse this process and push the abstracted memory of a visual object backward onto the brain's early visual processing areas and there mentally re-construct a representation of something. Representation is a key idea here. The authors point out that stored depictive representations are not like photographic pictures. They are simplified forms that can be re-presented and then examined and to which detail can be added. It may help communication designers to think of these abstracted representations as "brain icons" because they, like drawn icons, are simplified and focus on key features of an object or idea rather than inessential details. We can use these mental images to reason about problems, like whether a jar could squeeze into a crowded pantry shelf, or to communicate with people by creating images that connect with their visual imagery. It is important to note that understood this way, there is a deep and complex relationship between seeing and thinking that deserves attention.

COMPETING THEORIES

Kosslyn et. al. identify the core of the debate as two competing conceptions of the format we use to store internal visual representations: depictive



Depictive format above

FIGURE 1

FIGURE 2

Propositional format below

"two diagonal lines that meet at the top, joined halfway down by a short horizontal segment."

(Kosslyn et al., 2006, p. 12)

or propositional. The depictive approach suggests that our brain encodes images in a visual format using points, similar to the way a computer screen uses pixels. The blocks forming the triangle in Figure 1 illustrate a depictive format. The propositional approach suggests that we format images using abstract concepts like words in language or computer software. The words "two diagonal lines that meet at the top, joined halfway down by a short horizontal segment." in Figure 2 illustrate a propositional format for the same image.

The format used may seem like an academic debate, but it matters because the format of representation makes possible, or at least preferences, different kinds of thinking and from this the creation of different knowledge.

To settle the debate the authors call upon findings that add significant detail to the outline of the perceptual process noted above. Very early in this process the image from our retina is topographically mapped point-for-point on our brain. Objects close to each other on our retina are also close to each other on the cortical area called V1. There are, in fact, several topographically organized layers in V1 with each layer providing different kinds of processing. Cutting down through layers are columns that distinguish different line orientation, curve, value, and hue. These topographic layers are part of what Kosslyn labels the "visual buffer." The "visual buffer" then "reports" the results to other areas of the brain where patterns and shapes are assembled, where objects are formed and subsequently identified. Kosslyn asserts that through these successive stages a "population code" is assigned containing in abstracted form the key visual features that define an object. Kosslyn posits a "hybrid representation" that combines information for each point about its role in the depiction of the object, as well as additional abstracted information. "In spite of their coding nondepictive information, these hybrid representations cannot be reduced to propositional representations. Crucially, they use space (literally, on the cortex) to represent space in the world. The fact that each point codes additional information does not obviate its role in depicting the shape."

The highlight of Kosslyn's argument is that these encoded representations can be recalled and when they are, an image is reconstructed from memory using the same topographic neural space in the "visual buffer" that was used to "see" the initial image from the eye. In Kosslyn's words, the "stored shape representation is primed so strongly that activation is propagated backwards, including a representation of a part or characteristic in the visual buffer (which corresponds to the depictive image itself)." Kosslyn theorizes that we literally re-construct the object from memory and create a representation of it. These are mental images.

VALIDATION

When Kosslyn and his colleagues wrote this book some years ago the viability of their theory was still open to debate. But much has happen since then to support its basic premises.

In 1988 Tootell et. al. provided a foundation for how we see when they showed a topographically represented visual image mapped on the surface of a primate brain. Over the years various scientists have developed techniques that enable them to dye a primate brain and see there on the cortex - in real time - the images from the eye. A 2012 NIH presentation by Dr. Eyal Seidemann is one example of video showing this. ("Decision Related Activity and Top-down Attentional Modulations in Primate VI" http://videocast.nih.gov/summary.asp?Live=11769&bhcp=1) More recently researchers used fMRI to produce an image of a person's recalled memory (mental image) of a simple object. In 2014 Dr's. Cowen, Chun and Kuhl presented findings that through observing brain activity they were able to reconstruct recognizable individual faces from people's mental images of faces they were seeing ("Neural portraits of perception: Reconstructing face images from evoked brain activity" in *Neuroimage).* The title of the March 28, 2014 Fox news article reporting this paper was *"We know what you're thinking: Scientists find a way to read minds."* by Maxim Lott. While the face reconstruction study may be as much about the inventiveness of the computer processes employed as it is about the biological ones, its findings dramatically support the foundation of Kosslyn's hypothesis: mental images are seen reconstructed in the visual buffer. These studies can "see" them.

SO WHAT?

The Case for Mental Imagery may sound interesting to some readers, but to others the question "So what?" may have been lingering for some time now.

So what? How is the information in this book relevant to the designer? One answer is "A theoretical foundation for communication design." Communication design has entertained competing theories to guide practice. Some, such as semiotics, are based in linguistics. Theories of visual perception such as the one articulated by Kosslyn, Thompson, and Ganis may help provide more appropriate visual ground for a theory of visual communication. Knowing how people process, store, and use images is at the heart of visual communication. It's true that communication designers create objects that use both textual and visual forms to communicate and much has been written recently about the role of designer as author and the need for more writing in design education. Without dismissing the positive role designers can play in crafting the written content of the communication they create (designer as author), or diminishing the role writing can play for organizing and expressing thought in design classes (writing in design education), Kosslyn's theory suggests that there is a good reason that college "communication" programs focus on writing while "visual communication" programs focus on image making. Visual images are the essence of visual communication. Communication designers employ forms of communication that largely bypass language. Kosslyn reminds us that people think with images. One benefit of

Kosslyn's theory as it applies to design is that it is founded on hard-wired neurobiological perceptual processes common to all people, suggesting that design principles founded on this approach may be universal, applying to people of every age, language, literacy level, and culture. With limited research resources to invest, design might do well to focus on universal visual processes that can apply to nearly everyone before building upon theories focused on individual differences.

In addition to providing a theoretical foundation for visual communication, "Visual thinking" is another defense of the book's relevance. Kosslyn's theory, based as it is on depictive representations, means that visual designers use a visual language that is inherently more flexible and less inhibited by arbitrary encoding structures than language. Depictive reasoning can be more ambiguous and less structured than propositional reasoning. Images are more direct, less categorical, less overtly defined, and thus better suited for creative thinking and problem solving than language-based propositional representations that seem plodding by comparison. "I see" is a common visual-based metaphor for sudden understanding and an apt metaphor for visually-empowered design thinking.

"User centered" is yet another response. Kosslyn's theory means that communication designers now and in the future can reliably identify the mental images that people have, thus gaining direct insight into how to communicate with them more accurately. Designers who know their subjects' mental images can more reliably produce images that evoke the correct meaning. Knowing people's mental images moves user-centeredness into the user's head, literally. The point of view for designers might be transformative.

"Evidence-based" is another reply. Kosslyn's theory doesn't just apply to the front end of design creation, but also to the back end of design evaluation. Using people's mental images to evaluate communication objects could give not only very accurate measurement of communication but insight to corrective action. A loop of creation and evaluation based on reliable measurement of mental image may provide communication design with some solid principles for practice.

Another Paul Rand quote suggests a final answer when he states, "…the designer must steer clear of visual clichés by some unexpected interpretation of the commonplace." "Innovation" is the final answer. Design has been said to be the process of converting existing states to preferred ones. Designers don't just create what already exists; they create something new. So how can knowing the images people already have in their heads help create something new? To a designer the question is the answer. Knowing what people think enables us to take liberties, to explore novel variations and "unexpected interpretations", to both connect and expand what is in people's minds. Apart from knowing the people's mental images designers innovate in the dark, ignorant of whether their novel approaches support or hinder communication.

Kosslyn, Thompson, and Ganis' theory means several things to communication design. It means that seeing and thinking are complementary, helping to explain the effectiveness of information visualization. It means that visual communication designers who create images are directly connecting to the one of the most significant means people have for processing information, for thinking. It means that emphasis on visual thinking is one key to why design is good at creative problem solving.

If design theories should be founded on research findings in visual perception and cognition, then they will in some measure be founded on work by Kosslyn and his colleagues. It's a book that most designers should read.

Cowen, Chun, & Kuhl. (2014). "Neural portraits of perception: Reconstructing face images from evoked brain activity." Neuroimage

Kosslyn, Stephen M., Thompson, William L., & Ganis, Giorgio. (2006). *The Case for Mental Imagery*. New York, NY: Oxford.

Rand, Paul. (1970). *Thoughts on Design* (Third ed.). New York: Wittenborn Schultz.

Advisory Board

WELCOME

Visible Language wishes to welcome new advisory Board member Keith Crutcher. Keith reflects our interest in connecting to disciplines whose research is well-advanced and whose knowledge is related to visual communication.

Keith Crutcher

Keith A. Crutcher, Ph.D., has over 30 years of experience in biomedical research and technology including prior tenured faculty appointments at the University of Utah (7 years) and the University of Cincinnati (22 years), a founding role in an early stage drug discovery company (ApoLogic, Inc.), and four years serving as a Scientific Review Officer at the Center for Scientific Review at the National Institutes for Health. In the latter role, he managed the peer review of hundreds of grant applications. His academic research program, funded by the NIH, NSF, and other agencies, included studies of brain injury and Alzheimer's disease resulting in over 100 peer-reviewed publications, two issued patents, and numerous presentations. He has also served as an ad hoc reviewer for several federal agencies and private foundations as well as serving on the editorial boards of several journals including *Experimental Neurology*, *Aging Cell*, and *Neurobiology of Aging*, where he participated in the peer review of numerous manuscript submissions. He currently does consulting work for applicants seeking research funding and provides assistance in preparing proposals and navigating the peer review system at various federal agencies.

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Visible Language is an academic journal focused on research in visual communication. We invite articles from all disciplines that concern visual communication and would be of interest to designers.

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Visible Language, an academic journal, seeks to advance research and scholarship for two types of readers: academics and professionals. The academic is motivated to consume knowledge in order to advance knowledge thorough research and teaching. The professional is motivated to consume and apply knowledge to improve practice. *Visible Language* seeks to be highly academic without being inaccessible. To the extent possible given your topic, *Visible Language* seeks articles written to be accessible to both our reader types. Anyone interested may request a copy of our editorial guidelines for authors.

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Editorial correspondence should be addressed to:

Mike Zender
Editor, *Visible Language*
College of Design, Architecture, Art, and Planning
School of Design
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016
email: mike.zender@uc.edu

If you are interested in serving as guest editor for a special issue devoted to your specific research interest, write to the editor, outlining the general ideas you have in mind and listing a half dozen or so topics and possible authors. If you would rather discuss the idea first, call the editor at: phone number

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Sheri Cottingim
Office of Business Affairs
College of Design, Architecture, Art, and Planning
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016
telephone 513 556-4377
email: sheri.cottingim@uc.edu

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Before there was reading there was seeing. *Visible Language* has been concerned with ideas that help define the unique role and properties of visual communication. A basic premise of the journal has been that created visual form is an autonomous system of expression that must be defined and explored on its own terms. Today more than ever people navigate the world and probe life's meaning through visual language. This journal is devoted to enhancing people's experience through the advancement of research and practice of visual communication.

If you are involved in creating or understanding visual communication in any field, we invite your participation in *Visible Language*. While our scope is broad, our disciplinary application is primarily design. Because sensory experience is foundational in design, research in design is often research in the experience of visual form: how it is made, why it is beautiful, how it functions to help people form meaning. Research from many disciplines sheds light on this experience: neuroscience, cognition, perception, psychology, education, communication, informatics, computer science, library science, linguistics. We welcome articles from these disciplines and more.

Published continuously since 1967, *Visible Language* maintains its policy of having no formal editorial affiliation with any professional organization — this requires the continuing, active cooperation of key investigators and practitioners in all of the disciplines that impinge on the journal's mission as stated above.

Website
http://visiblelanguagejournal.com

Postmaster:
send address changes to:
circulation manager name
Office of Business Affairs
College of Design, Architecture, Art, and Planning
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016

Published tri-annually in January, May and October

SUBSCRIPTION RATES

United States	Individual	Institutional
1 year	$35.00	$65.00
2 year	$65.00	$124.00
3 year	$90.00	$183.00

Canadian*	Individual	Institutional
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Foreign**	Individual	Institutional
1 year	$ 56.00	$ 86.00
2 year	$107.00	$166.00
3 year	$153.00	$246.00

Prepayment is required. Make checks payable to University of Cincinnati *Visible Language* in U.S. currency only, foreign banks need a U.S. correspondent bank.

* Canadian subscriptions include additional postage ($9.00 per year).
**Foreign subscriptions include additional postage ($21.00 per year).

ISSN 0022-2224
Published continuously since 1967.
Index included in last issue of volume year.

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A limited number of nearly all back numbers is available. The journal website at http://visiblelanguagejournal.com is searchable and lists all issues, contents and abstracts.

Visible Language

the journal of visual communication research

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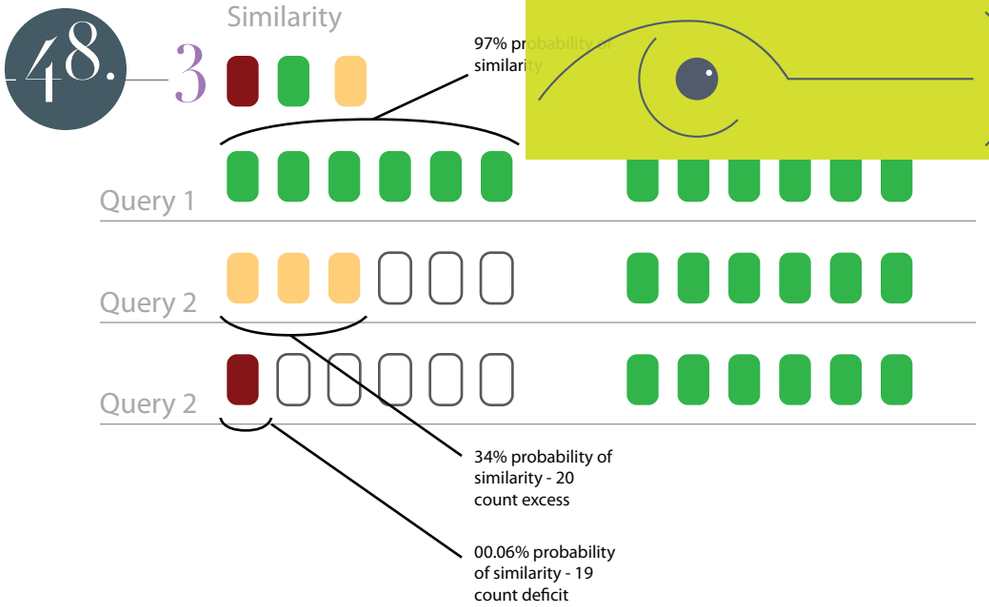
November 2014



visualization logic

50% – 100% probability of similarity = green

5% – 50% probability of similarity = yellow

less than 5% probability of similarity = red

six boxes filled in proportion to show inter-hospital similarities
six boxes need to show probability over/under 50%
six boxes can be rapidly enumerated (in about 1 second)

A Statistical Approach for Visualizing the Quality of Multi-Hospital Data

Connolly et. al.

ISSN 0022-2224

education theory

design principle

drill

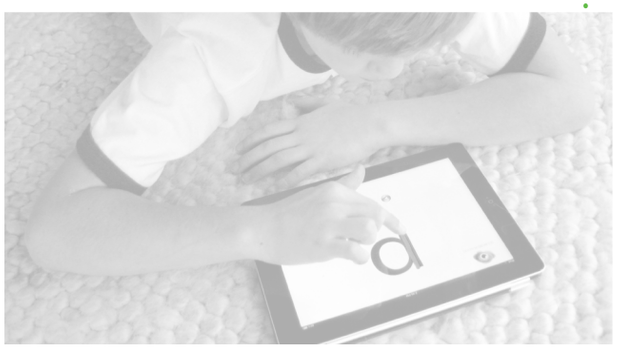
listen to sound

tactile

responsive

interaction

usability



universality

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Linking Design Principles with Educational Research Theories to Teach Sound to Symbol Reading Correspondence with Multisensory Typea

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Linking Design Principles with Educational Research Theories to Teach Sound to Symbol Reading Correspondence with Multisensory Type

4

Renee Seward, Beth O'Brien, Allison D. Breit-Smith, Ben Meyer

ABSTRACT

Designing products that are considered easy to use and beautiful, yet also effectively addressing the communication problem, can be a difficult challenge for any designer. This paper explains the development of See Word Reading™, a digital tool that explores letterforms when teaching beginning reading principles to children at risk of reading difficulties. After conducting a pilot study with this tool, we assert that dynamic type within digital technologies can offer an even greater opportunity to master alphabetic consolidation by using the engagement of multiple senses.

KEYWORDS

typography; reading; multi-disciplinary; technology; multi-sensory

INTRODUCTION

Billy is a precocious 5 year old who loves books. He interacts with them every opportunity he gets, whether it be at home, in the car, or waiting in the hair salon while his mom is getting her hair washed and trimmed. His favorite story is Goldilocks and the Three Bears. Every time he sees the icon for this story on the Smartphone, he can't help but touch it. After touching the icon he becomes immediately engrossed in the story because of the illustrated images and the friendly voice that is telling him the story as words appear on the screen. For Billy what makes this story all the more engaging is the fact he can touch the images and letters in the story and get them to make noises as the story is being read. He particularly likes petting the bears' heads to make them roar. To him this is the experience of learning early reading skills; to most of us who are 20 years and older this is a very foreign experience.

New technologies have changed the way children are interacting with images and type in the early stages of learning to read. A study conducted by the Internet security company AVG found that 19% of children between the ages of 2 and 5 know how to use a Smartphone or a tablet application whereas only 11% can tie their own shoelaces. Leap Frog, computers, iPads, and Smartphones allow for a much more hands-on approach to reading experiences. Previously, children were introduced to reading by sitting with their parents while they read a hardbound book. While the parent-child interaction is still happening and is very necessary, today's parents are sometimes replacing the hardbound book with a digital tablet. In fact, "The ubiquitous quality of technology is nudging literacy instruction beyond its oral and print-based tradition to the embracing of digital tools that utilize typography, imagery, and interactivity" (Holum, 2001). The usage of digital technologies inside the classroom is an increasing trend in education as well (Li, Pow, Wong, & Fung, 2010). Unfortunately many of the tools and applications being developed for these digital technologies look beautiful and seem purposeful, but they lack the depth in educational research to adequately address issues in reading instruction.

While opportunities exist for new types of reading experiences, the US still faces staggering concerns regarding literacy among children. The National Assessment of Educational Progress found that 33% of fourth graders and 24% of eighth graders in the US are at or below a basic level reading skills (National Assessment of Educational Progress, 2007). This means that about a 1/3 of our children are reading at merely a functional level.

With the rise of new digital technologies, 21st Century children are greatly immersed in digital reading experiences. This paper will explain the development of See Word Reading, a digital tool that explores the impact of multisensory letterforms on teaching beginning reading principles to children considered at risk of reading difficulties. Essentially this case study describes the evolution of a product design that is grounded in educational theories on reading and comprehension.

BACKGROUND

DEFINING READING

Reading is a complex skill informed by multiple sources of knowledge gleaned over time (Scarborough, 2009). One early source of reading knowledge involves discovering that phonemes heard in oral language can be mapped onto graphemes written on a page or screen. It is this understanding that researchers have referred to as "cracking the alphabetic code" (Stanovich, 1986; Storch & Whitehurst, 2002). The process of cracking the code for young children can be arduous but once broken opens a world of opportunities for children to access information via a new mode of communication beyond spoken language. Cracking the code is one step in the stages of reading acquisition that culminates in comprehension of what is read. Although reading is a skill of many dimensions, theoretical models of reading using a simple view suggest that reading is the multiplicative factor of print decoding and oral comprehension (Gough & Tunmer, 1986; Vellutino, Tunmer, Jaccard, & Chen, 2007).

FOUR STAGES OF LEARNING TO READ

Research conducted by Ehri (1987, 2005) suggests that children experience four stages of learning to read new words including pre-alphabetic, partial alphabetic, full alphabetic, and consolidated alphabetic stages. Within the pre-alphabetic stage young children are very aware of print in their environment and will "read" signs such as "McDonald's" based on their designs (i.e.,golden arches) not by the letters in the name of the restaurant. The second stage of reading is the partial alphabetic stage in which children recognize some letters of the alphabet, typically those letters in their names, but cannot yet recognize all of the letters in words. The third stage Ehri terms the full alphabetic stage. With the full alphabetic stage, children recognize all letters and letter sounds of the alphabet and make the conceptual breakthrough that letters of the alphabet represent speech sounds. The fourth stage is referred to as the consolidated alphabetic stage in which children learn that letter combinations represent speech sounds and that there are consistent rules or phonics rules for the sequence and combination of letters in words (e.g., -ate, -ike, -tion).

HOW READING IS TAUGHT TODAY

Essentially, the successful development of reading hinges on a child's ability to master phonemic awareness or the ability to "hear" small segments or phonemes within spoken words and then use those phonemic awareness skills to map speech sounds to the graphemes in a written word (Ehri's consolidated alphabetic stage)(Hammill, 2004; Swanson, Trainin, Necoechea, & Hammill, 2003). In fact, a defining characteristic of school-age children identified with reading disorders is a deficit in phonemic awareness abilities

(Morris, et al., 1998; Snowling, 2001; Hulme, Snowling, Caravolas, & Carroll, 2005). Thus research examining the effectiveness of phonemic awareness instruction for young children has shown causal relations between increasing skills in this area and proficient reading (Lonigan et al., 2009; Wagner, Torgeson, & Rashotte, 1994). As a result, one essential component of early childhood literacy curriculums includes phonemic awareness and phonics instruction that pairs sounds with letterforms.

Traditional methods of teaching early reading skills typically include teacher instruction that is orally presented (e.g., The letter "m" says /m/) through direct instruction via games and/or drill-based worksheets. This type of instruction has been shown to be effective for many children (Boyer & Ehri, 2011; Piasta & Wagner, 2010); however, it ignores the natural inclination and interest of young children in the 21st Century to learn information from new technologies. Furthermore, for children who struggle to learn to read, traditional methods of early reading instruction often does not prove entirely successful for every child (Carson, Gillon, & Boustead, 2013; Noe, Spencer, Kruse, & Goldstein, 2013). Therefore, educators need access to new approaches for teaching these skills that have been shown through research to be effective.

Multi-sensory approaches to teaching early reading skills that include a tactile component, such as the use of manipulatives (e.g., letters tiles) or body tapping have been shown to be effective in increasing struggling readers' reading skills in some cases (Campbell, Helf, & Cooke, 2008; Ritchey & Goeke, 2006). The basis of Howard Gardner's Multiple Intelligence theory is that the more senses you can engage while learning the more memorable the learning experience will be (Gardner, 2006). Maria Montessori, a pioneer of multi-sensory learning stated, "The hands are the instruments of man's intelligence" (Montessori, 1964, p.27). Yet a consistent missing component of many multi-sensory approaches involves the use of technology for teaching early reading skills. Moreover, a drawback of traditional methods is that they introduce an additional step of pairing phoneme counting (via tapping different parts of the body) to sound matching, then to matching the separate sounds to letters within words. A more direct multi-sensory method that involves one step in the sound-print correspondence mapping is likely more efficient for teaching early reading skills. One such method would be a digital interactive tool that affords explicit presentations of sound/letterform correspondences (i.e., multiple, rich visual images to represent each sound/letter pairin) within meaningful contexts).

MULTI-SENSORY TYPE VERSUS STATIC TYPE

Educational researchers and practitioners alike assert that the potential of new technologies for learning is likely to be found not in the technologies themselves but in the way in which these technologies are used as tools for learning (Means & Olson, 1995; Owston, 1997; Valdez et al., 1999). Leveraging a designer's ability to synthesize visual, tactile, and auditory qualities

into learning experiences within new technologies holds potential for explicit presentations of sound/letterform correspondences to be taught within the context of reading.

When looking at the context of reading with traditional print there are two issues that present themselves as they pertain to beginning readers. First, the uniformed system of glyphs has proven to be challenging for beginning readers to distinguish several letters. (Walker, S., & Reynolds, L., 2003, Sanocki & Dyson, 2011; Fiset, et al., 2008). In any good typeface there are always commonalties of stroke thickness, line and curve language, and x-height, and width between letters. For example, the letters "p", "g", "b", "d" prove a challenge because they are mirrors of each other and so it is difficult to discriminate between these letters (Colberg, 1992). "Barring certain minor idiosyncrasies of typeface design, the four letters are identical in every respect, except orientation in space" (West, 2009, p. 82).

Second, in addition to learning variation between letter categories, children must learn to ignore variations across different fonts in the way they represent the same letter. In the development of a typeface there are several letterforms that do not have the same anatomy as the letterform being taught in the classroom to beginning readers. For example the two-story "a's" visual form is very different from the one-story glyph with which teachers instruct students, and the letter "q" in most typefaces is missing the curve on the descender. The discrepancy between the way letterforms are taught and their representation within typefaces has been a significant source of confusion for students while learning to read and write (Bennett, 2005, p. 255), and in fact the development of abstracted letter units from such variations in lower case forms shows a protracted developmental period (Thompson, 2009). These issues can impede early readers from achieving Ehri's consolidated alphabetic stage of reading.

There are several typefaces that have been developed to address these issues, two of which are Read Regular (a typeface suggested for dyslexic readers) and Myriad Pro. Read Regular is a typeface which has been carefully drawn to maximize differences among the 26 letters of our alphabet. This differentiation can be seen in the shapes of the letterforms, as well as their counterspaces. (See Figure 1.) Myriad Pro, while not specifically designed for beginner readers, has proven to be an effective typeface due to its having a significant length on ascenders and descenders and nice open counterspaces. (See Figure 2.) These typefaces may offer some aid in letter discrimination on the path to Ehri's consolidated alphabetic stage by linking visually distinct letterforms to distinct sounds. However, we assert that dynamic type within digital technologies can offer an even greater opportunity to master alphabetic consolidation by using the engagement of multiple senses. Type onscreen provides more than just a static representation of an abstract glyph. Nicolas Kunz & Michael Flückiger (2009) stated, "Why should a typeface be rigidly set, if it is not going to be printed? In a dynamic medium, why shouldn't the form and the character of the typeface be understood dynamically as well?"

FIGURE 1

Read Regular has been carefully drawn to maximize differences among the 26 letters of our alphabet. This can be seen in the width of letters that are commonly the same like the a, e, o and c. The shape of the counterspaces in the bottom row, indicated through the diagonal line textures, have been careful drawn to appear as different as possible.

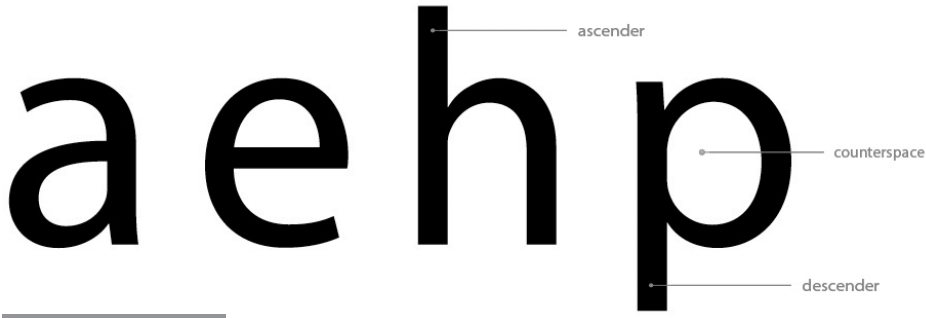


FIGURE 2

Myriad Pro has open counterpaces and the length of ascenders and descenders are very legible.

SEE WORD READING TOOL OVERVIEW

The See Word Reading tool, developed by School of Design and College of Education research faculty at the University of Cincinnati, is an experiential learning tool that explores the impact of multisensory letterforms on teaching beginning reading principles to children at risk of reading difficulties. There are three levels within See Word Reading™: Letter-sound Correspondence, Word Building Method, and See Word Reading Tool Overview. Within the Letter-sound Correspondence level, readers are introduced to individual letters and visual cues that are paired with them to aid in remembering their sound correspondences. Students are presented with the letter "p", for instance, and first trace the letterform with their fingers in the direction they have been taught to write. Upon successful tracing, the tool initiates a series of photographic images that begin with the letter's sound. (See *figure 3*.) For example, tracing the letter "p" initiates a sequence of images that appear embedded in the letterform, from peach to peppermint and then to pie, before the image resumes to the letterform alone. (see *figure 4*) Naming the images aloud cues readers to hear the common initial sound of the objects

FIGURE 3

This is a storyboard of the sequence of images that appear over time like after the letter has been traced.

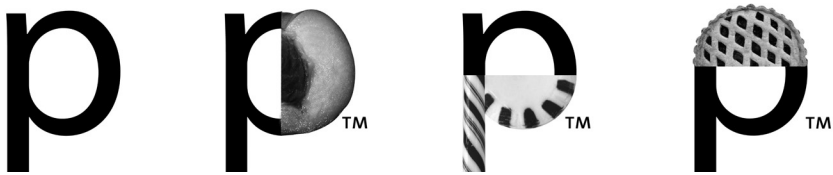


FIGURE 4

These are screen shots of the four levels to the digital tools. From left to right there is: The Letter-sound correspondence level where readers trace letters and or letter pairs with their finger to initiate the visuals cues; the Word Building level where readers add a sound tile to the word family to create a new word; the Storybook level where readers identify the sounds in the story that they have been prompted to find.

displayed (or the medial sound for some vowels). Readers are then asked to answer questions about the letter, including its name, corresponding sound, and a word that begins with that sound. All responses are recorded to a database that teachers can access later.

Within the second level, Word Building, readers begin to make words that utilize the sounds they are learning in the Letter-sound Correspondence level. A word rhyme pattern ('an') appears with a blank at the beginning, and students can select and drag a letter tile from the bottom of the screen to the word onset to fill in the blank and make a word. (See Figure 4.) Choosing a letter that does not make a word results in the letter tile falling back down to the letter tile bank at the bottom of the screen. If they cannot recall the sound that belongs to a letter and/or letter pairs, they can tap the letters to dynamically initiate the visual cues. Once a new word has been built, readers are prompted to verbally record themselves reading the word, and the verbal recording is sent to a database that teachers can access later. Teachers can pre-select a set of word families and onset letter choices for this level of the app.

Within the Storybook level a story is read to the students and the print is highlighted word by word as the children follow along with the reading. After the short story is read, students are prompted to find and touch letter(s) corresponding to a spoken phoneme. The letters here are dynamic, and if the correct letter and/or letter pairs are touched, the hidden cues associated with the letter and/or letter pairs reappear to reinforce the sound/ letter correspondences. (see *figure 4*)

LINKING DESIGN PRINCIPLES TO EDUCATIONAL RESEARCH

It was imperative that this tool fits like a glove for educators and their students. Many times designers make assumptions about a problem and fail to understand the pool of research existing on the problem yet still hope to create beautiful and fun artifacts. Many times these artifacts may be beautiful and fun but fail to truly address the problem they purport to address.

To avoid making such assumptions about this problem, as the See Word Reading prototype was being developed, rigorous critique sessions were conducted within the See Word Reading interdisciplinary team once to twice a month for a year to ensure that the tool was structured in a method supported by National Reading Standards. The interdisciplinary team consisted of two communication designers, a literacy specialist and an educational psychologist. The goal of the team was to pair graphic and interactive communication design principles with educational and cognitive research theories.

The pairing of graphic and interactive communication design principles with educational and cognitive research theories is seen in each level of the See Word Reading tool. Within the Letter-sound

Correspondence level, the series of visual image pairings to initial word sounds follows earlier cognitive research on the use of first-sound embedded picture mnemonics to relate phonemic sounds to the typographic letterform (See de Graaff, Verhoeven, Bosman & Hasselman, 2007.) Creating a memorable juxtaposition between the type and image by making formal connections helps readers to develop a mental model of the arbitrary sound-grapheme correspondences with letter-visuals pairings (Ehri, 2014). Thus at this Letter-sound Correspondence level of the tool, the method of image-symbol pairings is similar to what Ehri's pre-alphabetic readers do in the first stage of learning to read. They employ a similar strategy when they see the McDonald's golden arches logo and say the word "McDonald's". However for See Word Reading the strategically mapped images onto letterforms makes a direct connection between the image and type. According to Haber (1970) "memory for images is superior to memory for linguistic material" (cited in Colberg, 1992, p. 128). This was demonstrated in an experiment in which participants were able to recall 85 to 95% of 2,560 pictorial slides that they had viewed previously. Haber's research suggests the possibility that connecting images to linguistic material may effectively improve the recall of both. (See Standing, L., Conezio, J., & Haber, R. N. (1970).) These findings suggest that "images may aid retention…and maintain attention for (and interest in) meaningful linguistic material providing the visual relationship between the image and print [meaning letterform] are strong" (Colberg, 1992, p. 128).

Essentially, the See Word Reading tool consists of logotypes for all 44 sounds of the English language. Each image-to-letter pairing represents one logotype. (See *figure 5*.) The logotype system that was created for this tool is complex in that each sound within the English language can have as many as 4 different letter combinations to represent it; therefore there is a total of 78 letterform marks made to visualize the 44 sounds. The strength of the digital tool lies in the fact that each mark has been carefully crafted so that it carries the qualities that make for a good mark: distinctiveness, visibility, usability, memorability, universality, durability, and timelessness (Rand, 1994, Gernsheimer, 2008).

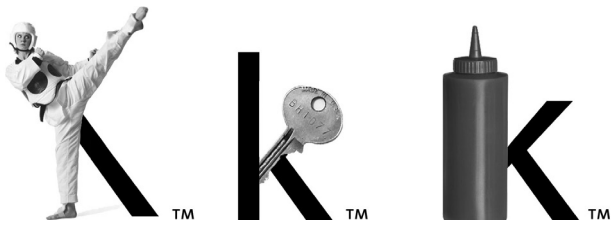


FIGURE 5

This figure show the logotypes developed for the /k/ sound.

Within the Word Building level readers are led to the processes used during Ehri's partial alphabet reading stage. In this stage readers know some letters but cannot recognize all the letters that would makeup a word. As students are engaging with the Word Building level they

can quickly build words with the letters they already know, and with the letters and/or letter pairs that they have not yet mastered they can access the hidden pre-alphabetic image cues then go on to build a word. The ability for children to still access the hidden image cues allows those between the developmental reading stages to still thrive. As readers become more established in the partial alphabet stage of reading they decrease the need to accessing the hidden images cues. Therefore, the cues serve as a scaffold (which is a cue that is given for a time then gradually taken away after students have mastered the concept) for learning at this level of the app, and the cues remain hidden when no longer needed. Readers learn at different paces; therefore, if readers need the additional cueing, they can use it while still being able to build words. The ability to access dynamically hidden cues within letterforms is a unique ability of digital interactive media.

The third Storybook level of See Word Reading is meant to support the transition from letter-sound learning to decoding within rich texts, and thus lead students toward Ehri's third and fourth stage of reading, the full alphabetic stage and the consolidated alphabetic stage. As noted above, in the full alphabet stage readers recognize that all letters of the alphabet represent speech sounds and in the consolidated alphabetic stage readers learn that letter combinations represent speech sounds and that there are consistent rules or phonics rules for the sequence and combination of letters in words (e.g., -ate, -ike, -tion). Within the fourth stage of the educational theory it is necessary that readers begin to decipher how learned letter-sound correspondences are consistent or differ across the contexts of different words. By searching for letter(s) that represent a given phoneme and only receiving positive feedback for correctly selected ones (e.g. the 'i' for /ī/ in the word 'big', but not in the word 'size'….), the Storybook level reinforces awareness of consistency beyond single letters to the letter pattern level.

In sum, See Word Reading capitalizes (1) on the educational and cognitive models of learning to read, (2) graphic and interactive communication design principles of embeding images as mnemonic devices within multiple levels of language (letter to word to text), (3) engaging tactile senses through tracing, touch and dragging behaviors to reveal new information overtime, and (4) engaging auditory senses through the audio sounds in order to draw readers through Ehri's four stages of reading development. Seeword Reading serves different types of learners by providing access to the pre-alphabetic image cues during all levels, thus providing a scaffolding so that all individuals can progress through the levels. The access to these hidden cues in all levels addresses the importance of children's ability to master and then in turn use those phonemic awareness skills to map speech sounds to the graphemes in a written word (Hammill, 2004; Swanson, Trainin, Necoechea, & Hammill, 2003).

Typically, assistive technology for reading simply tells students the sound a letter makes: however, with See Word reading

students are cued to recall the sound associated with the letter by the visual images and then prompted to produce the letter sound orally. Also, other programs (such as Hooked on Phonics) use a paired associate type of learning; however the associations are made through flashcards outside the context of reading text. In contrast, by embedding image cues within the letterforms in See Word Reading, readers can make letter-sound associations within the context of on screen reading further, by allowing the students to reveal the cues as needed with a touch, the learning process becomes scaffolded rather than assistive. Scaffolding is an educational technique of giving support to students during the learning process with the intention of helping students achieve their learning goals (Sawyer, 2006). As students begin to master the goal, the tool is gradually taken away. This allows for individualization of instruction where the children and also the teachers can realize which phonemes are difficult and require further instruction.

The Teacher's Backend Tool

In addition to providing support for readers, the See Word tool was developed to assist teachers in individualizing instruction. To this end, the tool collects data during the interactive learning sessions by tracking children's spoken and tactile interaction with the letters – and all data is accessible to the teacher through the backend interface. The backend capabilities that record all student interactions allows a teacher to learn where students are struggling so that further interventions can be establish to help the student learn. The tool tracks task completion times, and it records the children's verbal and tactile interactions at each level, providing information about various early literacy skills.

Grapho-motor and visual recognition is assessed at the letter level as children trace then visually match and sound out the letter. Level 1 tracks letter tracing time and records verbal and tactile responses to the questions being asked. Encoding is assessed at the word level as children build words and pronounce them. Level 2 tracks how many attempts it takes readers to build a word then goes on to record the children's verbal reading of the built words. Letter-sound decoding is assessed at the text level as children search for letters in a text that correspond to a given sound. Level 3 records the time it takes readers to find each sound they were prompted to find. Results from a pilot study (below) demonstrate how interactive digital text can serve as a pedagogical tool for tracking student progress.

A PILOT STUDY USING THE SEE WORD READING TOOL

OBJECTIVE

Once a prototype of the tool was developed, the interdisciplinary team col-

lectively wrote for grants and designed a pilot study as a proof of concept. This pilot study had two main objectives. First, to understand the usability of the tool for both the students and trained research teachers. The second objective was to gain some early preliminary data on how and in what way the tool aids in improving students' reading ability.

METHOD

The design of the pilot study was a randomized controlled design. Students enrolled in an urban after-school program were recruited into the study by the after-school coordinator and K-1 teachers sending home consent forms to parents. Then students with parental consent were randomly assigned to one of two groups. The See Word Reading group learned phonics with the ipad-based See Word Reading tool, whereas a control group used math, science and art focused applications on the ipads. Both groups received reading instruction during the school day with their classroom teachers, but after school the students in the See Word Reading group received additional reading instruction time whereas the control group did not. Matched pairs of students were randomly assigned to one of the two groups; students in pairs were matched on pre-test scores of letter-sound knowledge (Clay,2002).

Groups met 3 times per week. Within the See Word Reading group children worked in small groups of 4 with trained research teacher (undergraduate students in education) for 30 minute lessons for a total of 10 lessons taught over 20 sessions. Each lesson was taught twice, included 10 minutes of instruction at each of the 3 levels of See Word Reading, and focused on 3-4 phonemes. Twenty-six phonemes were trained in total, wherein the most common consonants and vowels are taught first in the study (Common Core State Standards for English Language Arts and Literacy, Appendix A, p. 17). Within the control condition each session was led by a trained research teacher (undergraduate student in education) who introduced a series of math, science, and art focused applications on the iPad. These activities were unrelated to reading or pre-reading skills and were intended as a control for gains resulting from simply trying something new and working on the iPads. Without given the control access to applications on the iPad any gains in the measures could be considered as novelty effects, which would affect the validity of the outcomes. The novelty effect is the tendency for students to improve because of their increased interest and attention to the new technology introduced, not because they actually learned pre-reading and reading skills from the See Word Reading Tool (Clark & Sugrue, 1988).

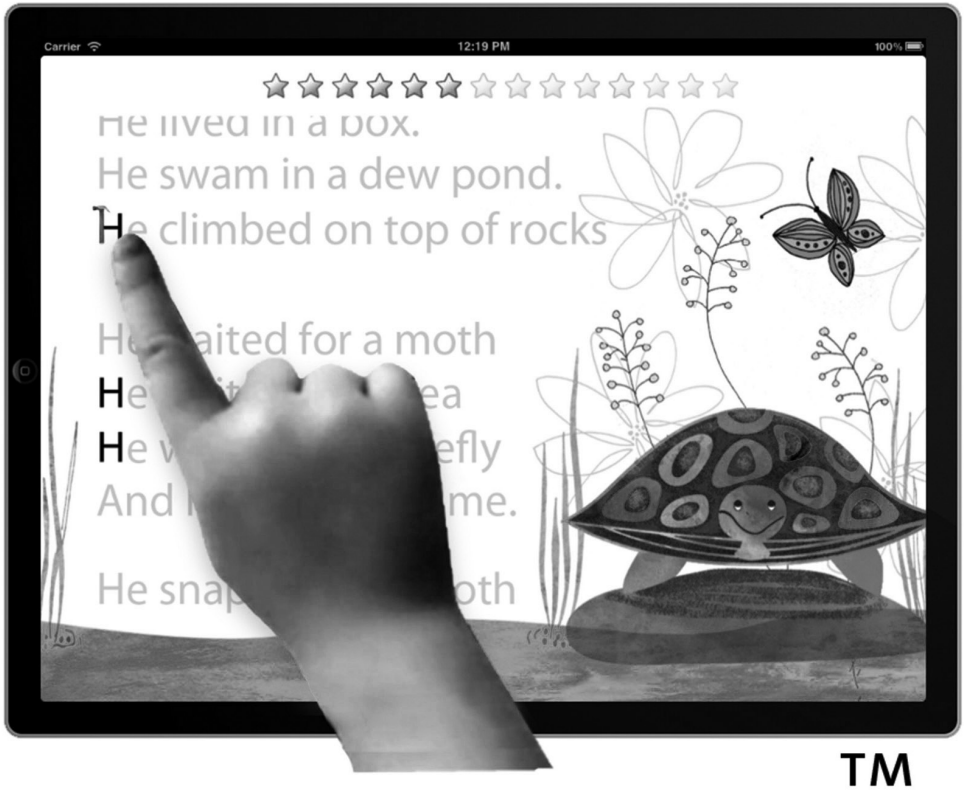
During each testing session of the pilot study, an educator and a designer were present to make observations of how well the tool was functioning for both the educators and students. The interdisciplinary team met often throughout the 17 weeks, along with the trained

research teachers, to address critical problems with the tool. Adjustments were then quickly made so that it functioned better for the teachers and the K-1 students in the following sessions.

One of the early usability issues found with the tool was the communication of the navigation button, which advanced readers through the series of questions being asked in the Phonemic Awareness level. The buttons were initially word-based buttons, but since the students could not read, icon-based buttons proved more functional. Within the Storybook level, we found it was helpful to install a timer to determine how long the students would search for a particular sound in a story. Without the timer, the students were easily frustrated when they couldn't find all sounds, and they wanted to quit looking. Subsequently, a progress bar made of stars was added to the Storybook level. (See Figure 6.) This bar let the children know how many instances of a particular sound they needed to find and it kept track of their progress. We found that frustration set in

FIGURE 6

The Storybook level progress bar is made of stars which helped readers to know how many sounds they needed to find.



without this bar and there was not a clear incentive for them to keep looking for sounds. With the bar they were eager to be the first to find all the letters and get all the stars on their bar lit up.

Part of the tool is individualizing instruction and provides teachers with information about individual students regarding specific phonemes/graphemes they may struggle to learn. To assist teachers in this manner, the backend of the tool provides information about student interactions with the app. For example, in Level 1, the child responds to the question "What letter is this?" by selecting from a full keyboard the letter that matches the glyph that they had traced. The teacher can access stored data regarding how many attempts it took each student to identify each letter. With this information, the teacher can then focus on the letters with which each student is having difficulty. For example, in the two figures below (Figures 7 and 8), data were plotted from two more advanced students (102 and 103) compared with two weaker students (016 and 004) with regard to how many tries they needed to correctly match each letter. The weak students had very low baseline scores on a letter-sound test (2), whereas the stronger students had higher baseline letter-sound scores (10). Their performances were plotted across the entire set of lessons, shown on the x-axis as the graphemes that were taught each lesson (with first lessons beginning at the left and last lessons ending at the right of the graph). As can be seen, each of the poorer students showed a different pattern of difficulty. In particular, 016 had the most difficulty early on and with potentially confusable letters such as "p" and "q" and " b" and "d." Student 004 demonstrated more difficulty during mid-sessions, particularly with letters, "g, n," and "i" and in later sessions with the vowel pairs, "ea" and "oo."

RESULTS

All students in the experimental and control groups were given pre-test and post-test measures, including a word identification (Woodcock-Johnson III Tests of Achievement [WJIII] Word Identification subtest, Woodcock et al., 2007) and spelling task (Spelling Inventory measure, Bear et al., 2007). The word identification task included the Word Identification subtest from the WJII, which is a standardized, norm-referenced test of children's ability to read letters and high frequency words in isolation. The spelling task included the Spelling Inventory from Bear et al. (2007) in which children spell words to dictation. The spelling words are then scored according the developmental spelling model presented in Bear et al. (2007).

Average pre-to-post gain scores on each of these tasks are shown in Figure 9 and 10. According to ANCOVAs with gain score as the dependent measure and pre-test scores on the dependent measure and letter-sound knowledge entered as a covariates (to control for auto-regressive effects), there was a trend for group differences in spelling gains, $F(1, 19) = 3.78$, $p = .06$, $\eta 2 = .166$. Group means indicated that the See Word Reading group made somewhat greater gains overall (from pre- to post-test)

TABLE 1

Table 1 shows the number of errors made by pupils when matching a letter(s) to an audible dictated letter-sound. The errors are calculated by the number of attempts students made to correctly match the letter to the sound. The chart isolates individual data across different sessions for three students; one student with weaker skills (016) compared to two stronger students (103 and 102). The results of this chart show that as the weaker student (016) progressed through See Word Reading the number of errors made while matching sound to letters decreased and became similar to the stronger students.

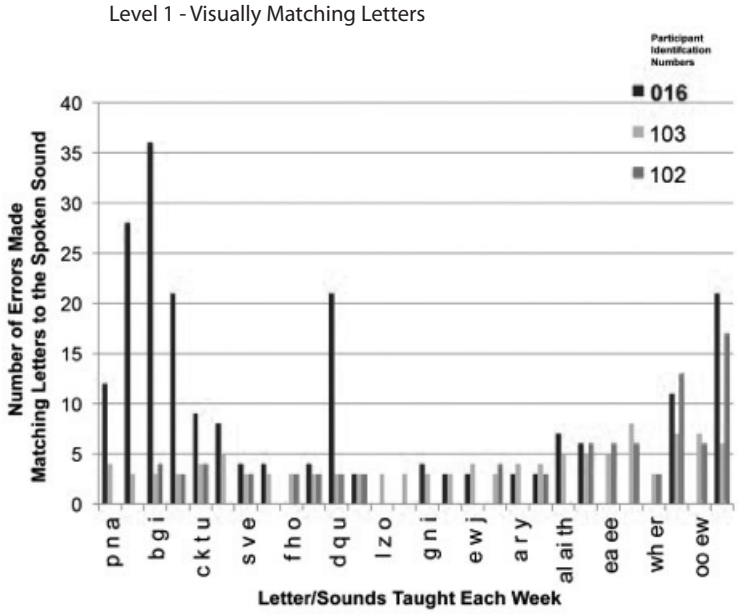
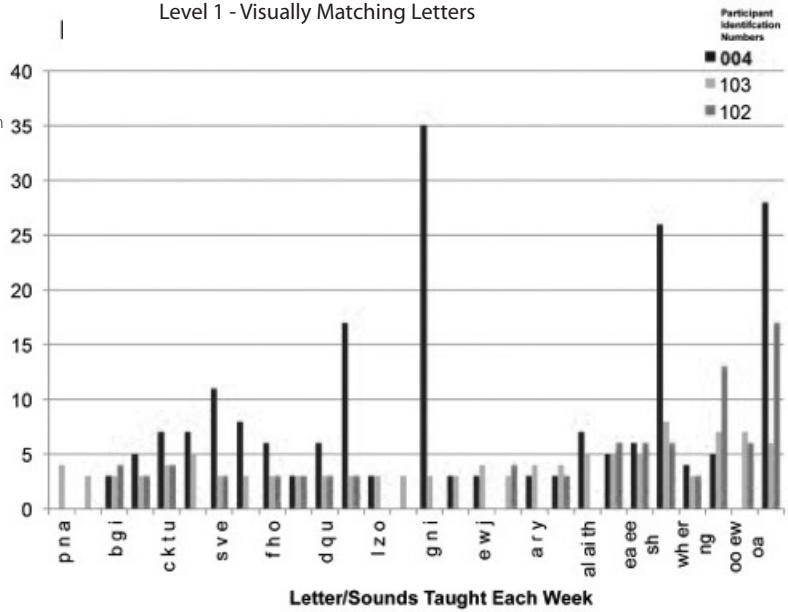


TABLE 2

Table 2 shows the same individual data on Level 1 visual letter matching as Table 1, except the comparison looks at the same two stronger students (103 and 102) compared to another weaker student (004). In this case, the weaker student (004) showed difficulty on particular lessons with specific letter-sounds.



in the number of correctly spelled word features (Msw=4.24, Mc=1.95). The group effect for gains in word identification was not significant, F(1, 21) = 0.56. Although the effect was not statistically significant, the See Word Reading group also showed a higher mean word identification gain across the intervention (Msw=5.50, Mc=3.71 standard score units). Given the small sample size and low power, such trends are still promising.

TABLE 3

The boxplots shown here represent performance by the two groups, control (white box) and experimental (grey box), on a word identification task. Performance is plotted as the gain in standard score units (change from pre- to post-test). The line inside each box represents the group's median gain score, while the top and bottom of the box represent the 3rd and 1st quartile scores, respectively, for the group. Whiskers show the minimum and maximum gain scores in each group.

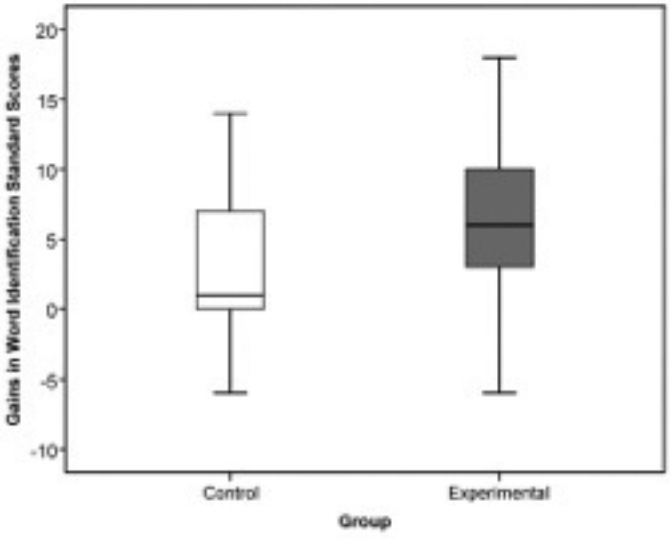
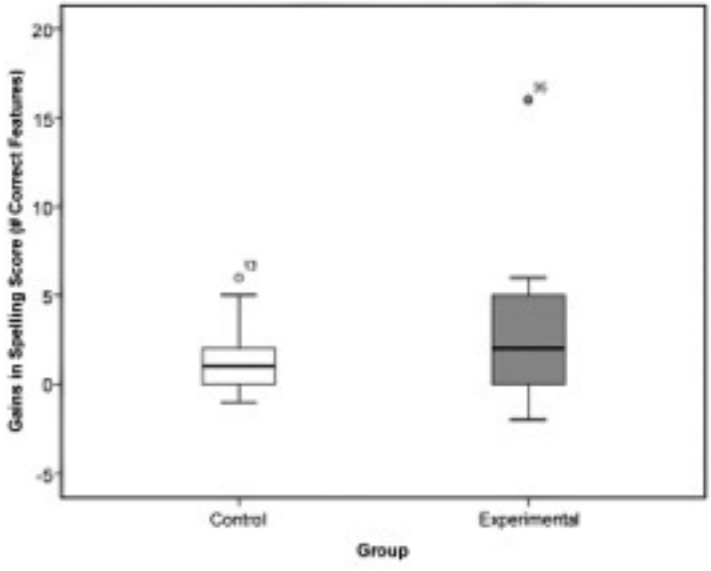


TABLE 4

Boxplots, similar to Table 3, represent group performance, here on the spelling measure. Median gain scores from pre- to post-test are indicated by the line in each box, for the control group (white box) and the experimental group (grey box).



CONCLUSION

The purpose of the development of See Word Reading tool is to serve as a case study that shows the evolution of a design that is grounded in educational research theories. While the landscape of learning to read has changed due to the influence of new digital technologies, the design of educational tools has to address the current needs of education, including the grounding of these tools in educational and cognitive theories and the testing the effectiveness of these tools in facilitating learning. To date many classroom teachers have much skepticism toward new educational tools' ability to improve education. It is our belief this is due to the fact that, while many of the early applications looked beautiful and were fun to interact with, they were not grounded in educational research theories and were not tested for their effectiveness in aiding student's learning. While the See Word Reading tool shows a trend towards improving spelling and word identification, conclusions are limited by the small sample size. Further investigations need to be conducted with a larger sample size of kindergarten and first grade students in order to see if the tool will produce statistically significant outcomes.

Currently in design there is a lot of discussion about the importance of user-centered design and how engaging in this process will result in stronger outcomes. Often this user-centered approach focuses solely on understanding the behaviors, motivation, and frustrations of a defined user set. Understanding the usability of a design is important and was an integral part of this pilot study, but also having a clear understanding on how to implement visual communication principles to the discipline specific theories of any given discipline is a critical aspect of design. It is our belief that this tool showed a positive trend in outcomes because of this pairing.

Most disciplines stand on a foundation that is built with theories that guide their existence. The value of pairing communication design principles to those discipline specific theories can produce outcomes that are not only easy to use and beautiful but also effective to educate.

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AUTHORS

Renee Seward

Renee Seward is a tenure seeking Assistant Professor of Graphic Communication Design in the College of Design, Architecture, Art, and Planning. Ms. Seward's role in the team is visual communication design and interaction design method to develop the reading tool. She is the creator who is designing See Word Reading tool, which teaches children sound/symbol correspondence. Ms. Seward brings this project her expertise in Universal Design for Learning.

Beth O'Brien

Beth O'Brien, Ph.D., is a Senior Research Scientist at the National Institute Of Education, Singapore. She brings expertise from her studies on text processing and developmental reading disorders, as well as research design. She is instrumental in designing the research methods, including the assessment selection and data analysis. She brings to the project her extensive experience in researching interventions for children with dyslexia and reading disorders.

Allison D. Breit-Smith

Allison D. Breit-Smith, Ph.D., is a tenure seeking Assistant Professor of Literacy in the College of Education, Criminal Justice, and Human Services, in the School of Education. She brings expertise on literacy experiences related to early childhood. She oversees the fidelity of the work of the GA's who will be collecting the data. She is instrumental in commenting on how well the tool is meeting the needs of teachers to teach reading. She brings to the project her extensive experience with early reading instruction.

Ben Meyer

Ben Meyer is an Associate Professor Educator of Graphic Communication Design in the College of Design, Architecture, Art, and Planning. His role on the team involved interaction development and programming. He is the developer who programmed See Word Reading tool, which teaches children sound/symbol correspondence. He brings to this project his knowledge in mobile application development and programming.

Book Review:

Design for information, an introduction to the histories, theories, and best practices behind effective information visualizations.

by

Isabel Meirelles

Beverly, MA: Rockport Publishers, 2013.

Jorge Frascara

Design for information is a thorough representation of both the field of information visualization and the research interests of the author, whose focus is on "the theoretical and experimental examination of the fundamentals underlying how information is structured, represented and communicated in different media."

Beginning with the "big picture," the book includes an amazing collection of examples, the most thorough I have seen to date in a volume. The author organizes the content according to several categories represented by the titles of the chapters: 1. Hierarchical structures: trees; 2. Relational structures: networks; 3. Temporal structures: timelines and flows; 4. Spatial structures: maps; 5. Spatio-temporal structures; and 6) Textual structures. An appendix, notes, a bibliography, a contributors list, and an index complete the content of the book.

Design for information is an extensive taxonomy of data visualization types and is "a must" for anybody interested in the work done in the area. Each one of the hundreds of examples is explained and discussed, forming a kind of encyclopedia on the subject. It seems that nothing escaped the exemplary collection that Meirelles assembled. The discussions and explanations normally focus on what information is represented and how it is represented.

It is interesting to see, as well, how many different professional fields today use diagrams to organize and represent information: basic science, applied science, education, engineering, medicine, and technologies, etc. The value of the book is centered on the inclusion of examples of how many different problems are now being addressed through data visualizations, how many historical efforts preceded whatsoever is

done today, and how the advent of the computers have allowed the field to explode by handling large data sets as well as dynamic representations.

At the end of the examination of the 224-page volume I became curious as to how these diagrams might have performed with the users they were intended for in terms of ease of comprehension; what conclusions I could arrive at from an evaluation of the examples from a perceptual and cognitive human factors perspective; or how a complementary book could contribute to the development of best practices. I would not expect that one volume could be so extensive as this one and also cover the field critically. However, I have to wonder how the super-complex visualizations permitted by computer programs today would perform regarding comprehension, memorization, and use of the information presented. The discussion on perception and cognition is very brief, and it might leave some readers wondering about the assertions made: they are proposed as principles without them being discussed. This topic, as well as Gestalt theory, are not considered during the description of examples. The size of some reproductions is too small to assess their quality as data visualizations. They appear as examples of problems addressed but not as information in themselves. To compensate for this, the book includes valuable URLs for people interested in seeing in better detail many of the diagrams shown.

While the above issues could be perceived as weaknesses, the strength of the book is its truly amazing array of examples and the rare historical diagrams it offers. It also displays an uncommon erudition and includes an extensive and useful bibliography. I do not know how long Meirelles took to complete the manuscript, but it feels like a lifetime project. These assets, coupled by excellent production, make this an indispensable publication for anyone interested in information visualization.

Book Review:

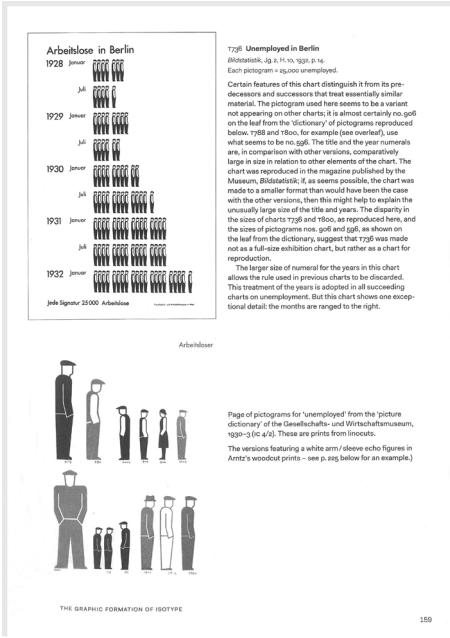
Isotype: Design and contexts 1925–1971

by

Burke, Christoher; Kindel, Eric; Walker, Sue (Eds.)

Hyphen Press, London, 2013

Per Molleup



Page 158
Males with flat cap and hands in pocket stereotype unemployed persons. Striking workers have crossed arms.

Isotype, why not?

The term Isotype, an acronym for International System Of TYpographic Picture Education, is a technique of data visualization introduced by sociologist, economist, and philosopher Otto Neurath. Originally called "The Vienna School of Pictorial Statistics" and developed and practiced at the Gesellschafts- und Wirtschaftsmuseum in Wien (Social and Economic Museum of Vienna), 1925-34, Isotype's purpose was to communicate societal information to visitors. In 1935, Neurath's technique was renamed, and Isotype began its own life and was used for other purposes in other places.

Isotype builds on the idea expressed in Neurath's often-repeated adage, "To remember simplified pictures is better than to forget accurate numbers" (p. 85). Therefore, Isotype is best known for Picture tables—graphic displays with rows of repeated pictograms each standing for a number of real world units. The picture tables embody the proposition that it is easier to compare quantities by comparing numbers of well-presented symbols, than to compare symbols of different size. Pictograms in the Isotype picture tables are scaled: in a display showing unemployment, each pictogram would stand for 1,000; 100,000; or 1 million – or another round number of unemployed persons. In picture tables, the reader must count the pictograms in different groups and multiply with the scaling factor to get the total amounts. The number of the repeated pictograms in a picture table is most often rounded off. Some Isotype picture tables feature half, quarter, or smaller fractions of pictograms. Even then, Isotype displays are typically not as precise as the numbers they represent.

Isotype: Design and contexts 1925-1971 describes Isotype in a period delimited by 1925 when the Gesellschafts-und Wirtschaftsmuseum in Wien was founded and 1971 when the Isotype Institute in London closed. The book comprises 12 chapters dealing with the genesis and further development and design of Isotype. The book includes two kinds of information; it describes Isotype design principles, and it describes the process by which Isotype was developed and disseminated. To this reviewer the former part is the most interesting, while the latter part serves as a useful historical backdrop.

TEACHING MUSEUM

In the first of two central chapters, Christopher Burke covers the ten-year lifetime of The Gesellschafts-und Wirtschaftsmuseum in Wien including the formative years of Isotype. The idea behind Isotype predated the museum. Otto Neurath, sociologist, economist, and philosopher, had already applied charts with pictorial descriptions of quantities for the Museum für Siedlung und Städtebau, Museum for Settlement and Town Planning. Eager to educate by means of these didactic tools, Otto Neurath suggested a new museum to expand the ordinary population's understanding of national and world relations. The social democrat regime in Vienna understood the importance of education and provided the necessary financial support.

Otto Neurath invented Isotype, but more than that, he promoted it. Philosophically and organisationally trained in addition to being well connected academically and politically he spread the word and established the connections that were vital to the incubation of a new idea like Isotype. Neurath partnered his strong interest in education of ordinary people with his equally strong social commitment resulting in his belief that progress depends on knowledge, and knowledge should be delivered in ways that are both attractive and memorable – essential qualities of Isotype.

The Gesellschafts und Wirtshaftsmuseum in Wien was not a museum in the traditional sense of that word; and therefore consistent with Neurath's view that "The modern museum should be a teaching museum, a means of education, a schoolbook on a grand scale…" (p. 30). The Gesellschafts and Wirtshaftsmuseum in Wien consisted primarily of graphic charts explaining societal matters, first and foremost quantities. The museum introduced a number of advanced ideas to meet its audience. To accommodate prospective visitors the museum was open evenings and Sunday mornings. Also, the museum branched out at several places where visitors would be. At a certain time, the museum would exhibit at several different locations in Vienna including the town hall. A central corner shop museum open in the lunch hours had as many as two thousand visitors a day. At the corner shop special interactive knowledge machines were placed where visitors could test their knowledge – anticipating a distant, digital future. Exhibition material was reused and exchanged between permanent

and time limited exhibitions in several places. Along with its own exhibitions, the museum took part in fairs and exhibitions in Austria and abroad.

The museum also published books, pamphlets, and journals to reach its audience in time and space. *Gesellschaft und Wirtschaft*, Society and Economy, was a collection of 100 Isotype charts. *Fernunterricht*, distant teaching/learning, later renamed *Bildstatistik*, Pictorial Statistics, prefigured modern distance learning.

Three persons led the development of Isotype: Otto Neurath, a sociologist, economist, and philosopher; Marie Reidemeister, a German academic; Georg Arntz, a German graphic designer.

Austrian Otto Neurath's past career included his initiative to, and directorship of, the German museum of war economy in Leipzig during WWI. After the war, his presidency of the Central Office of Economics, in the Bavarian Soviet Republic, was followed by a conviction of assisting high treason and an eighteen-month, later suspended, prison sentence. In 1920, Neurath was back in Vienna to become the director of the Forschungsinstitut für Gemeindewirtschaft, Research Institute for Co-operative Economy. In this capacity Neurath initiated a Museum for Settlement and Town Planning, which within a year – also on Neuraths initiative – was replaced by The Gesellschafts-und Wirtschaftsmuseum in Wien.

Marie Reidemeister (after 1940 Marie Neurath) met Otto Neurath before the start of the Gesellschafts- und Wirtschafts Museum in Wien, became his right hand, and continued working with Isotype after Otto Neurath's death in 1945. Most importantly, Marie Reidemeister played and developed the role of 'transformer'. Otto Neurath and Marie Reidemeister considered the 'transformation' of a message into a principle for a graphic chart the crucial part of the work with Isotype. Transformation was the link between science and graphic design. According to Marie Reidemeister: "We think out which is the point that has to be brought home, and then we try to do so in such a way that everybody will grasp it. We avoid distracting the attention from the more important issues." (p. 15). Also according to Marie Reidemeister, other designers impressed by Isotype would emulate the form but hardly master the transformation (p. 14). Today, the term 'transforming' is not used, but the substance is a natural part of the work of information designers engaged in data visualisation in news media and elsewhere.

Georg Arntz was a German artist working with woodcuts in precise graphic shapes, which caught the attention of Otto Neurath. Georg Arntz began working for the museum in 1928 and in 1929 moved to Vienna where he developed the schematic graphic form that became a signature quality of Isotype. In the process he also changed the technical production from paper cuts to printing from linocuts.

Three conditions for launching Isotype were present. First, a strong-minded initiator with a firm social and educational commitment who was well connected politically; second, highly qualified principal collaborators; and third, a friendly political market.

Partly inspired by the political winds and the following possible need for a foothold outside Austria, Otto Neurath established in 1932 the affiliate Mundaneum to take care of international relations. In 1932 and 1933, Mundaneum established branches in Amsterdam and London respectively. In 1934, the International Foundation for the Promotion of the Vienna Method of Visual Education was established in The Hague. Later in 1934, when the political situation in Austria and Vienna as envisioned by Neurath became dangerous, he, his wife Marie Reidemeister, Georg Arntz, and two other collaborators moved to the Netherlands. The Gesellshafts- und Wirtschaftsmuseum was closed. Part of its material was already transferred to Mundaneum. The rest was seized by the new regime, not the first time a design initiative has been subject to political change. In 1940 the Neuraths moved on to England.

THE NETHERLANDS

Two chapters of the book deal with the continuous work in the Netherlands and England. In Vienna, Isotype had been a means to inform the visitors of the Gesellschafts- und Wirtschaftsmuseum. In the Netherlands the Neurath team had to earn their way from projects. Otto Neurath wrote two books in Basic English: *International Picture Language* and *Basic by Isotype*. Other jobs included production of a children's theatre puppet show and an art exhibition, *Rondon Rembrant*. Also, commissions resulted from Otto Neurath's frequent travels to the USA.

ENGLAND

When Germany occupied the Netherlands the Neuraths moved on to England, where Otto Neurath had been promised a teaching position at Oxford. The Isotype Institute was then established in 1942. The Isotype work in England followed two lines. The Neuraths wrote and designed a number of books for Adprint, a book packager who also published, and they worked on informative films together with British film producer John Rotha. The books dealt with the war effort and social policy. Apart from a couple of booklets this work included a three book series: *America and Britain*, *The Soviets and ourselves*, and *New Democracy*. Two chapters in *Isotype: Design and contexts 1925-1971* deal with film work and children's books respectively.

FILM

Documentary filmmaker John Rotha approached the Neuraths soon after their arrival in England to initiate a collaboration concerning films for the Ministry of Information. The first film, *A few ounces a day* about saving waste to be used in the war effort, was based exclusively on animated Isotype graphics. The Neuraths acted as de facto directors and Maria Neurath made a complete storyboard as well as the graphics to be animated. Later followed several films, where Isotype animations were combined with live action. A series of films that had significant results included, *Worker and*

warfront, which was shown for workers in factory canteens, *World of Plenty* and *Land of promise* which dealt with food and with planning respectively.

In 1945 Rotha established a special company, Unifilm, with himself and Otto Neurath as directors. After Otto Neurath's death Marie Neurath would continue the cooperation with John Rotha until 1948, when Unifilm closed down. In 1954 Marie Neurath contributed to a TV series, *The World is ours*, and in 1965 to a film *The physics and chemistry of water*.

The film work was not without problems. Some critics found that serious matters should not be treated through the genre of animation. The Neuraths complained when they did not have full control of the work, and Paul Rotha did not always find the necessary support for Isotype work from the Ministry. Professional designers recognise these kinds of problems. Otto Neurath also had some didactic reservations. Isotype on paper lets the viewer see and compare several displays concurrently in space, while film – working in time – doesn't provide that possibility. Also paper media, in contrast to film, gives viewers as much time as they want. Today video technology has solved this problem.

CHILDREN'S BOOKS

In her chapter about children's books Sue Walker rightly states that "The children's books produced by the Isotype Institute provide an excellent insight into Marie Neurath's work as a transformer and show that she had a particular skill in making charts and illustrations that were accessible to children of all ages." (p. 391). This chapter reaches beyond children's books: The account of Marie Neurath's approach is relevant to all designers concerned with data visualisation.

The children's book production took place from the 1940s into the 1970s. Otto Neurath took the initiative, but after his death Marie Neurath edited, wrote, and designed a large number of children's educational books, some of which were schoolbooks. Children's book series included *If you could see inside*, *I'll show you how it happens*, *Visual history of mankind*, *Visual science*, *Wonders of the Modern world*, and *Wonder world of nature*. The Isotype institute delivered both the text and design for these books. Illustrations would include pictograms and all kinds of explanatory drawings. In another series, *They lived like this*, the majority of the illustrations were drawings of contemporary artefacts. This series was co-written by external artists.

Marie Neurath's thoughts about the work with children's books are interesting to everyone working with data visualisation:

> I had to ask myself: what are the essential things we want to show, how can we use comparison, direct the attention, through the arrangement and use of colour, to bring out the most important things at the first glance, and additional features on closer scrutiny. Details had to be meaningful, everything in the picture had to be useful for information. (p.395)

From a note addressed to the readers of the second book in the Visual history series:

> Everything which would not help you understand the meaning, or which would confuse you, is left out. Colours are used only to help make the meaning clearer, never simply as decoration. This means that every line and every colour in these pictures has something to tell you. (p. 403)

USA

Three factors obstructed Isotype's introduction into the USA. The timing was not good. It was the middle of the depression, there were several imitators (just competitors?) around, and there was Rudolf Modley, a former part-time employee in the administration of the Gesellschafts- und Wirtschaftsmuseum in Wien. Rudolf Modley would cooperate and compete with the Isotype team in Den Hague and Oxford, and challenge Otto Neurath's views.

A group of influential supporters worked together to get Otto Neurath and Isotype to the USA. When in 1930 there was an opportunity to use Isotype at the Museum of Science and Industry in Chicago, Otto Neurath recommended the employment of Rudolf Modley. Here and later Modley acted more independently than envisaged by Otto Neurath.

In 1934 the supporters founded the Organizing Committee for the Institute for Visual Education "to establish in the United States an organization which can develop and promote the graphic methods of presenting social and economic facts, which have been characterised by the Vienna Method as exemplified in the work of the Gesellschafts- und Wirtschaftsmuseum in Wien under the direction of Dr. Otto Neurath" (p. 307). When the organisation did not follow Modley's advice, he created his own company, Pictorial Statistics Inc. Otto Neurath and Rudolf Modley held differing views. Neurath wanted standardised pictograms designed centrally while Modely had a more relaxed view. Neurath explained:

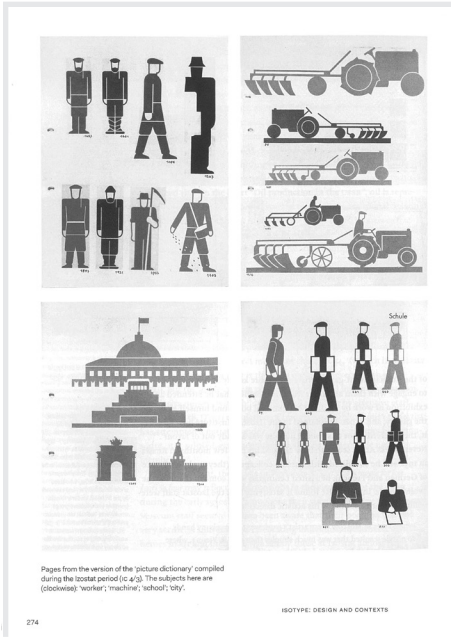
> That is to say, for our picture language one general list of a limited number of signs is needed for international use, and this has to be worked out by or under the control of one chief organization (This organization is now the ISOTYPE work-room at the Hague). (p. 332).

Also, Modley saw the pictograms as elements that could have their own life while Neurath saw pictograms as parts of visual arguments enabled by transformation. Modley was not interested in transformation. In line with this view he published symbols sheets with pictograms to be used by everyone and a book entitled, *1000 Pictorial Symbols* (1942).

Otto Neurath travelled to the USA several times and secured important commissions, primarily in the health sector. Isotype also delivered illustrations to *Compton's pictored encyclopedia* (1939) and Otto Neurath wrote *Modern man in the making* (1939) for Knopff publishers. After Neurath's death Marie Neurath wrote an essay on Isotype for Henry Dryfuss's *Symbol Source Book* (1972).

RUSSIA

The Isotype team's efforts in Russia took place from 1931-1934. Russia did not want to commission Isotype work from Vienna. Instead, they wanted Isotype staff to help establish a Soviet institute. A special organisation named Izostat was established with Otto Neurath as one of two directors, and several Isotype staff would join them for shorter or longer periods. The total staff at times would be as high as 75. A number of problems hindered cooperation. The work primarily dealt with visualising the established success of the first five-year plan 1928-1932 and the predicted success of second five-year plan 1933-1937. While The Vienna Method as practiced in Vienna was based on empirical facts, the Russians wanted forecasts to play an essential role. The estimates were often exaggerated. Another problem was that the Russians wanted naturalistic pictograms aligned with wanted Soviet realism. Also, the Russians wanted more, sometimes propagandistic, illustration. The cooperation resulted in some publications with more or less Viennese influence. Georg Arntz made a series of charts for Izvestia, charts for exhibitions, and a number of publications more or less influenced by the Isotype team. One Isotype idea was used with a new meaning. In the Vienna Method black was sometimes used to illustrate worse, while red would stand for better. In Russian charts red would stand for Russia while black would stand for other nations.



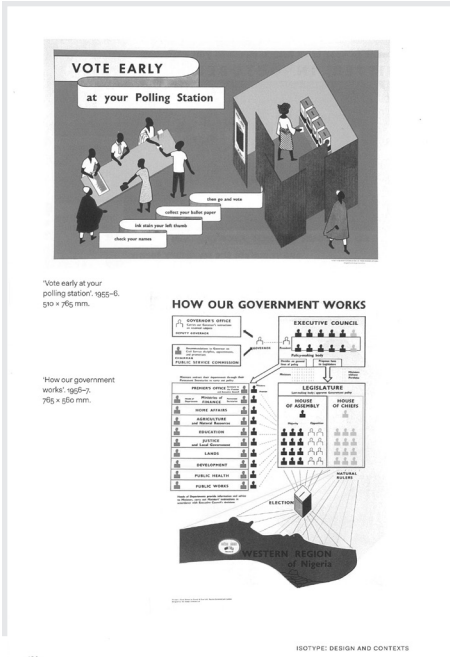
Page 174
Isotype work for Izostat in Moscow characterised by Russian realism.
(original in color)

In 1934 the Russians wrote to Otto Neurath that the contract did not comply with Russian law and the amount due at the end of the contract would not be paid. The latter incident was a major blow to the Isotype organisation, which in Den Hague depended on paid work. Izostat continued without Isotype help until 1940.

AFRICA

Some Isotype work in Africa took place from 1952-1958. Otto Neurath reportedly said that Isotype was not for the Viennese, but for the Africans (p. 449). In 1943 he worked on a proposal for an exhibition for the British Colonial Office entitled, *Human life in Africa*. This project did not materialize.

In 1953 a partnership between Buffalo Books, a subsidiary of Adprint, the Isotype Institute, and Purnell and Sons, a printing firm, planned and published the magazine *Forward* addressing the three British colonies Gold Coast (Ghana), Sierra Leone, and the Western Region of Nigeria soon to become independent. A trial issue and an issue number 1, dealing with culture, adventure, sports, and practical advice were published before the magazine was determined to be economically impossible in 1953.



'Vote early at your polling station', 1955–6. 510 × 765 mm.

'How our government works', 1956–7. 765 × 560 mm.

Page 480
Isotype work with limited abstraction for Western Region, Nigeria, promoted participation in an upcoming election. *(original in color)*

In 1954 Marie Neurath wrote a memorandum sketching what Isotype could do in the Western Region of Nigeria. It included a visual explanation of the aims of the government and the establishment of a local workshop for Isotype run by trained Nigerians. Marie Neurath visited Africa three times and a series of booklets and poster-leaflets were produced, while the workshop remained a plan.

For the Western Region a series of 16-page White Paper Booklets were published including *Education for all in the Western region*, *Better farming for better living in the Western Region*, *Health for all in the Western Region*, and *Paying for Progress in the Western Region*. Also a series of poster-leaflets dealing with health issues was produced. As indicated by the name, the poster-leaflets worked both as wall charts and as folded leaflets to take away. A following visit to the Western Region resulted in commissions for a new series of booklets.

Compared with the Western Region in Nigeria the Gold Coast and Sierra Leone had little work for Isotype. In 1956 Isotype made one leaflet for The Gold Coast, *The Volta River Project: what it means to you*, and in 1957 one for Sierra Leone *Voting, general election*.

In the late fifties the Isotype work in Africa came to an end. The chapter author, Eric Kindel, offers a number of probable explanations, one being the distance, another being the failure to establish a local workshop with trained local people. To the Isotype Institute the African experience meant realising the need for locally adapted symbols for man, woman, house, and more. The pictograms should 'speak'. In the same vein, charts were given familiar backgrounds. According to Marie Neurath: "[A]dherence to the method cannot go as far as imposing an alien background on those unable to share one's experience of it." (p. 495). This did not, according to Marie Neurath "imply that the system had to be radically changed" (p.495).

DESIGN

In the second central chapter of the book, Robin Kinross presents the design of Isotype. This chapter was originally a part of Kinross's MPhil thesis from 1979. (Robin Kinross is the owner of Hyphen Press, the publisher of this book as well as Otto Neurath's 'visual biography': *From hieroglyphics to Isotype* (2010) and a string of well presented books on typography.) The provenance of the chapter may explain the order in which it deals with the subject. The description begins with the formats of the wall charts, and moves through

colour, male and female, qualifying symbols, and guide pictures, down to pictograms and configuration. In the latter part Kinross codifies six types of displays dealt with by Isotype. This would have been a natural start of the chapter to be followed by pictograms. Apart from this peculiar arrangement the chapter gives a robust description of the elements used in Isotype. Kinross calls Isotype "a coherent approach to ordering material in graphic form" (p.107). It covers what we today call 'data visualisation'. In contrast to the remaining part of the book, Kinross offers a few critical remarks on Isotype.

Considering Neurath's interest in education it is remarkable that there exists no manual, no single, document explaining the Isotype design principles thoroughly. One reason could be that Isotype remained a work in progress. Another reason could be that Neurath did not want everyone to design visual displays, but rather to commission the displays from the initiators. So-called notes, single sheets each describing a design subject, were descriptive rather than prescriptive. They described current practice more than recommending what should be done. Also, Neurath's publication, *International Picture Language*, 1936, written in Basic English doesn't serve as a manual either.

Kinross's description of Isotype design gives a clear impression of Isotype being a work in progress. Pictograms, qualification, grouping of pictograms, use of colour, use of typography, and configuration would change considerably between 1925 and 1934, especially after Georg Arntz joined the team. However, this development did not always follow a straight line. Different principles were sometimes used concurrently; old design features were sometimes used after new design features were introduced. The development involved standardization, modularization, and simplification. Pictures would be reused and be combined; the use of colours would be restricted.

Kinross refers to the common misunderstanding that "quantified rows and columns" "might be typical of the work as a whole" (p. 142). Well, these picture tables and their pictograms are what most of us think about first when we think about Isotype. The picture tables and their pictograms are featured on the covers of publications and wherever Isotype is discussed. Kinross shows the width of Isotype by the following classification (p. 139).

Charts showing quantified material:

1. rows and columns [picture tables],
2. division of a whole (usually a checker-board),
3. geographically ordered pictograms and more diagrammatic charts,
4. quantities related to area (usually showing densities),
5. flows.

Charts showing non-quantified material:

Neurath broke down the picture table category into six sub-categories (p. 140):

1.1 comparison of total quantities,
1.2 where sizes of constituent parts are interesting, as well as total quantities,
1.3 where relative sizes of constituent parts are most important,
1.4 to make a shift particularly clear; alignment left and right to form an axis,
1.5 where the sizes of parts and of wholes are equally important; one compares both horizontally and vertically,
1.6 to allow comparison of parts and wholes, and to make a shift clear; especially important in showing changes over time.

A schematic drawing and an Isotype picture table illustrate each of these sub-categories.

While the fact that a large part of the text of this chapter is devoted to picture tables and pictograms may support the idea that Isotype first and foremost is picture tables, the book's numerous illustrations establish some balance. Isotype is both picture tables and a general approach to data visualisation.

In a chapter about pictograms, Christopher Burke confirms that a direct line from the Isotype pictograms to the pictograms used in transport and communication today hardly exists. However, qualities such as standardization, modularity, and schematization are parts of the Isotype heritage. Isotype pictograms worked in lines in picture tables to compare something, while modern pictograms in transport and communication simply point to the existence or condition of something. Otto Neurath, however, suggested that the Isotype pictograms could possibly also be used for public information signs. This application was not realised.

WHY NOT?

Isotype: Design and contexts 1925–1971 is a comprehensive introduction to the Isotype idea. The book's 12 chapters written by nine authors are well planned with a minimum of overlaps. While the main text goes into considerable historical detail, the illustrations present the elements and charts by which Isotype should be known and appreciated. The numerous illustrations – more than 400 – and their elaborate captions turn the book into a portable archive, which for everybody unable to access the Isotype collection at University of Reading will remain the most important Isotype resource.

Implicitly the book relays a well-known phenomenon: how a design idea born to solve one problem if successful becomes a

solution that looks for other problems. From informing the Viennese citizens the problem changed into finding potential outlets for the newfound method.

In the beginning of *Isotype: Design and contexts 1925–1971* Christopher Burke states, "The best way to bring these [the qualities of Isotype] to the fore is to examine it as a historical phenomenon in all the complexities of its contexts." (p. 14). This is questionable. To compare is the basic function of Isotype. Isotype should itself be compared with competing data visualizing formats. How can we evaluate the virtues of airships without comparing airships with other airborne vessels?

We still need a balanced discussion of the qualities of Isotype. What exactly is the Isotype approach? How does it survive today? How does Isotype compare with the display formats that news media and others prefer today? What are the pros and the cons of Isotype compared with other more frequently used data visualising formats such as bar charts, bubble charts, and line charts? Understandability, accuracy, attraction, and memorability are factors that should be discussed. The discussion should also include the intended target groups of Isotype and the contemporary audiences of news media and professional literature. Is Isotype only for uneducated people?

One probable finding is that most contemporary audiences prefer exact information to the visual explanation offered by Isotype picture tables. Today bar charts, pie charts, and bubble charts, which in principle present *visual* messages, are as a rule supplied with exact figures. Such displays are hybrids. They are half visual display, half table. The visual part lets the reader get a fast idea, while the figures deliver accuracy. In a short period Isotype's picture tables were also supplied with exact figures. In later displays the figures were abandoned. The big, undisputable advantage of isotype displays is that they are attention grabbing and attractive to look at. The visual attraction may be accompanied by good memorability.

P S

Design and contexts 1925-1971 is well crafted with a pleasing design. However, there are two minor flaws. First, the key to source abbreviations is located on page 18, while readers expect to find it in the beginning of the book where it would be easy to retrieve for later reference. Second, tiny, alphanumeric caption designations of up to four characters are written with lowercase numerals (6 and 8 with ascenders and 3, 4, 5, 7, and 9 with descenders), which are difficult to read, especially when presented in the very small type used for marginalia.

Per Mollerup
14 August 2014

THE MOST IMPORTANT DESIGN BOOKS MOST DESIGNERS HAVE NEVER READ:*

The Case for Mental Imagery

by

Stephen M. Kosslyn, William L. Thompson, and Giorgio Ganis

Mike Zender

date: 2035 CE
location: a design office

The designer looked at the screen and watched the child's memory of being sick. "I'm sorry to ask you this, but think of diarrhea again please," she said. The toilet shimmered into view briefly followed by transparent wavy lines. The designer noted the lines, then replayed the other children's memory and noted that 67% of them included shimmering, wavy lines to represent smell. "Thank you, that's all I needed. You've really helped me design this icon," she said.

Paul Rand once said that communication design is about "saying the commonplace in an uncommonplace way." (Rand, 1970, p. 36) This suggests that effective communication is essentially enhancing the familiar. For visual communication design, this means creating unique images that will connect in predictable ways with the images people already hold in their minds. From this perspective, the whole user-centered design movement is a cultivation of means for designers knowing, not just assuming, the mental images people have. Stephen Kosslyn, William L. Thompson, and Giorgio Ganis' book *The Case for Mental Imagery* (Kosslyn, Thompson, & Ganis, 2006, p. 4) gives designers an accurate glimpse into how mental images work.

MENTAL IMAGES

The plausibility of the fictional design office above hinges on the answer to a debate that has raged for at least decades, perhaps centuries: do we see mental images or not? According to Kosslyn, Thompson , and Ganis, "A mental image occurs when a representation of the type created during the initial stages of perception is present but the stimulus is not actually being perceived." Mental imagery is seeing what is not there, not an illusion or a mirage, but seeing in our mind something familiar and then perhaps using that mental image to think with or solve a problem. We might experience this by answering this question: how many windows face the street in your house or apartment? Given this task most people gaze blankly for a second

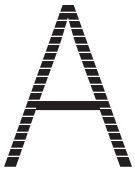
or two as they push into memory an image of their house and then briefly count the windows in the image. Kosslyn et. al. cite similar questions such as "Do you know which is darker green, a frozen pea or a pine tree? Or the hand in which the Statue of Liberty holds the torch" as examples where people use mental imagery.

Belief that this phenomena exists are not new. The authors briefly note that thinkers from the classic Greeks to Einstein claimed to use mental images "in memory, problem solving, creativity, emotion, and language comprehension." However, introspective experiences are notoriously difficult to study, easy to refute, and thus ripe territory for endless debate. Kosslyn, Thompson, and Ganis use Chapters 2 and 3 to detail the debate, Chapter 4 to marshal empirical findings from a broad range of cognitive psychologists and neuroscientists in order to settle the debate, and Chapter 5 to articulate a well-founded theory of mental imagery.

The theory articulated in the book is based on the process of visual perception which it describes. The eye is just the start of a process that occupies much of the brain. In fact, approximately 50% of the cerebral cortex is devoted to visual processing. The brain is not like a general-purpose computer with generic processing capacity to which are downloaded different problems for analysis. Rather, the brain is like a special purpose device with different neurons in different regions hard-wired to accomplish specific tasks. Vision is one of the brain's largest tasks. In visual perception a huge volume of sensations are processed and reduced to simpler more organized forms. It's as if individual camera pixels are processed for simple features then structured into units that correspond to distinct objects and key properties that define and distinguish those objects from each other. Kosslyn and his colleagues propose that we can reverse this process and push the abstracted memory of a visual object backward onto the brain's early visual processing areas and there mentally re-construct a representation of something. Representation is a key idea here. The authors point out that stored depictive representations are not like photographic pictures. They are simplified forms that can be re-presented and then examined and to which detail can be added. It may help communication designers to think of these abstracted representations as "brain icons" because they, like drawn icons, are simplified and focus on key features of an object or idea rather than inessential details. We can use these mental images to reason about problems, like whether a jar could squeeze into a crowded pantry shelf, or to communicate with people by creating images that connect with their visual imagery. It is important to note that understood this way, there is a deep and complex relationship between seeing and thinking that deserves attention.

COMPETING THEORIES

Kosslyn et. al. identify the core of the debate as two competing conceptions of the format we use to store internal visual representations: depictive



Depictive format above

FIGURE 1

FIGURE 2

Propositional format below

"two diagonal lines that meet at the top, joined halfway down by a short horizontal segment."

(Kosslyn et al., 2006, p. 12)

or propositional. The depictive approach suggests that our brain encodes images in a visual format using points, similar to the way a computer screen uses pixels. The blocks forming the triangle in Figure 1 illustrate a depictive format. The propositional approach suggests that we format images using abstract concepts like words in language or computer software. The words "two diagonal lines that meet at the top, joined halfway down by a short horizontal segment." in Figure 2 illustrate a propositional format for the same image.

The format used may seem like an academic debate, but it matters because the format of representation makes possible, or at least preferences, different kinds of thinking and from this the creation of different knowledge.

To settle the debate the authors call upon findings that add significant detail to the outline of the perceptual process noted above. Very early in this process the image from our retina is topographically mapped point-for-point on our brain. Objects close to each other on our retina are also close to each other on the cortical area called V1. There are, in fact, several topographically organized layers in V1 with each layer providing different kinds of processing. Cutting down through layers are columns that distinguish different line orientation, curve, value, and hue. These topographic layers are part of what Kosslyn labels the "visual buffer." The "visual buffer" then "reports" the results to other areas of the brain where patterns and shapes are assembled, where objects are formed and subsequently identified. Kosslyn asserts that through these successive stages a "population code" is assigned containing in abstracted form the key visual features that define an object. Kosslyn posits a "hybrid representation" that combines information for each point about its role in the depiction of the object, as well as additional abstracted information. "In spite of their coding nondepictive information, these hybrid representations cannot be reduced to propositional representations. Crucially, they use space (literally, on the cortex) to represent space in the world. The fact that each point codes additional information does not obviate its role in depicting the shape."

The highlight of Kosslyn's argument is that these encoded representations can be recalled and when they are, an image is reconstructed from memory using the same topographic neural space in the "visual buffer" that was used to "see" the initial image from the eye. In Kosslyn's words, the "stored shape representation is primed so strongly that activation is propagated backwards, including a representation of a part or characteristic in the visual buffer (which corresponds to the depictive image itself)." Kosslyn theorizes that we literally re-construct the object from memory and create a representation of it. These are mental images.

VALIDATION

When Kosslyn and his colleagues wrote this book some years ago the viability of their theory was still open to debate. But much has happen since then to support its basic premises.

In 1988 Tootell et. al. provided a foundation for how we see when they showed a topographically represented visual image mapped on the surface of a primate brain. Over the years various scientists have developed techniques that enable them to dye a primate brain and see there on the cortex - in real time - the images from the eye. A 2012 NIH presentation by Dr. Eyal Seidemann is one example of video showing this. ("Decision Related Activity and Top-down Attentional Modulations in Primate VI" http://videocast.nih.gov/summary.asp?Live=11769&bhcp=1) More recently researchers used fMRI to produce an image of a person's recalled memory (mental image) of a simple object. In 2014 Dr's. Cowen, Chun and Kuhl presented findings that through observing brain activity they were able to reconstruct recognizable individual faces from people's mental images of faces they were seeing ("Neural portraits of perception: Reconstructing face images from evoked brain activity" in *Neuroimage).* The title of the March 28, 2014 Fox news article reporting this paper was *"We know what you're thinking: Scientists find a way to read minds."* by Maxim Lott. While the face reconstruction study may be as much about the inventiveness of the computer processes employed as it is about the biological ones, its findings dramatically support the foundation of Kosslyn's hypothesis: mental images are seen reconstructed in the visual buffer. These studies can "see" them.

SO WHAT?

The Case for Mental Imagery may sound interesting to some readers, but to others the question "So what?" may have been lingering for some time now.

So what? How is the information in this book relevant to the designer? One answer is "A theoretical foundation for communication design." Communication design has entertained competing theories to guide practice. Some, such as semiotics, are based in linguistics. Theories of visual perception such as the one articulated by Kosslyn, Thompson, and Ganis may help provide more appropriate visual ground for a theory of visual communication. Knowing how people process, store, and use images is at the heart of visual communication. It's true that communication designers create objects that use both textual and visual forms to communicate and much has been written recently about the role of designer as author and the need for more writing in design education. Without dismissing the positive role designers can play in crafting the written content of the communication they create (designer as author), or diminishing the role writing can play for organizing and expressing thought in design classes (writing in design education), Kosslyn's theory suggests that there is a good reason that college "communication" programs focus on writing while "visual communication" programs focus on image making. Visual images are the essence of visual communication. Communication designers employ forms of communication that largely bypass language. Kosslyn reminds us that people think with images. One benefit of

Kosslyn's theory as it applies to design is that it is founded on hard-wired neurobiological perceptual processes common to all people, suggesting that design principles founded on this approach may be universal, applying to people of every age, language, literacy level, and culture. With limited research resources to invest, design might do well to focus on universal visual processes that can apply to nearly everyone before building upon theories focused on individual differences.

In addition to providing a theoretical foundation for visual communication, "Visual thinking" is another defense of the book's relevance. Kosslyn's theory, based as it is on depictive representations, means that visual designers use a visual language that is inherently more flexible and less inhibited by arbitrary encoding structures than language. Depictive reasoning can be more ambiguous and less structured than propositional reasoning. Images are more direct, less categorical, less overtly defined, and thus better suited for creative thinking and problem solving than language-based propositional representations that seem plodding by comparison. "I see" is a common visual-based metaphor for sudden understanding and an apt metaphor for visually-empowered design thinking.

"User centered" is yet another response. Kosslyn's theory means that communication designers now and in the future can reliably identify the mental images that people have, thus gaining direct insight into how to communicate with them more accurately. Designers who know their subjects' mental images can more reliably produce images that evoke the correct meaning. Knowing people's mental images moves user-centeredness into the user's head, literally. The point of view for designers might be transformative.

"Evidence-based" is another reply. Kosslyn's theory doesn't just apply to the front end of design creation, but also to the back end of design evaluation. Using people's mental images to evaluate communication objects could give not only very accurate measurement of communication but insight to corrective action. A loop of creation and evaluation based on reliable measurement of mental image may provide communication design with some solid principles for practice.

Another Paul Rand quote suggests a final answer when he states, "…the designer must steer clear of visual clichés by some unexpected interpretation of the commonplace." "Innovation" is the final answer. Design has been said to be the process of converting existing states to preferred ones. Designers don't just create what already exists; they create something new. So how can knowing the images people already have in their heads help create something new? To a designer the question is the answer. Knowing what people think enables us to take liberties, to explore novel variations and "unexpected interpretations", to both connect and expand what is in people's minds. Apart from knowing the people's mental images designers innovate in the dark, ignorant of whether their novel approaches support or hinder communication.

Kosslyn, Thompson, and Ganis' theory means several things to communication design. It means that seeing and thinking are complementary, helping to explain the effectiveness of information visualization. It means that visual communication designers who create images are directly connecting to the one of the most significant means people have for processing information, for thinking. It means that emphasis on visual thinking is one key to why design is good at creative problem solving.

If design theories should be founded on research findings in visual perception and cognition, then they will in some measure be founded on work by Kosslyn and his colleagues. It's a book that most designers should read.

Cowen, Chun, & Kuhl. (2014). "Neural portraits of perception: Reconstructing face images from evoked brain activity." Neuroimage

Kosslyn, Stephen M., Thompson, William L., & Ganis, Giorgio. (2006). *The Case for Mental Imagery*. New York, NY: Oxford.

Rand, Paul. (1970). *Thoughts on Design* (Third ed.). New York: Wittenborn Schultz.

Advisory Board

WELCOME

Visible Language wishes to welcome new advisory Board member Keith Crutcher. Keith reflects our interest in connecting to disciplines whose research is well-advanced and whose knowledge is related to visual communication.

Keith Crutcher

Keith A. Crutcher, Ph.D., has over 30 years of experience in biomedical research and technology including prior tenured faculty appointments at the University of Utah (7 years) and the University of Cincinnati (22 years), a founding role in an early stage drug discovery company (ApoLogic, Inc.), and four years serving as a Scientific Review Officer at the Center for Scientific Review at the National Institutes for Health. In the latter role, he managed the peer review of hundreds of grant applications. His academic research program, funded by the NIH, NSF, and other agencies, included studies of brain injury and Alzheimer's disease resulting in over 100 peer-reviewed publications, two issued patents, and numerous presentations. He has also served as an ad hoc reviewer for several federal agencies and private foundations as well as serving on the editorial boards of several journals including *Experimental Neurology*, *Aging Cell*, and *Neurobiology of Aging*, where he participated in the peer review of numerous manuscript submissions. He currently does consulting work for applicants seeking research funding and provides assistance in preparing proposals and navigating the peer review system at various federal agencies.

JOURNAL INFORMATION

Visible Language is an academic journal focused on research in visual communication. We invite articles from all disciplines that concern visual communication and would be of interest to designers.

READERSHIP

Visible Language, an academic journal, seeks to advance research and scholarship for two types of readers: academics and professionals. The academic is motivated to consume knowledge in order to advance knowledge thorough research and teaching. The professional is motivated to consume and apply knowledge to improve practice. *Visible Language* seeks to be highly academic without being inaccessible. To the extent possible given your topic, *Visible Language* seeks articles written to be accessible to both our reader types. Anyone interested may request a copy of our editorial guidelines for authors.

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Editorial correspondence should be addressed to:

Mike Zender
Editor, *Visible Language*
College of Design, Architecture, Art, and Planning
School of Design
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016
email: mike.zender@uc.edu

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Sheri Cottingim
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College of Design, Architecture, Art, and Planning
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016
telephone 513 556-4377
email: sheri.cottingim@uc.edu

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Before there was reading there was seeing. *Visible Language* has been concerned with ideas that help define the unique role and properties of visual communication. A basic premise of the journal has been that created visual form is an autonomous system of expression that must be defined and explored on its own terms. Today more than ever people navigate the world and probe life's meaning through visual language. This journal is devoted to enhancing people's experience through the advancement of research and practice of visual communication.

If you are involved in creating or understanding visual communication in any field, we invite your participation in *Visible Language*. While our scope is broad, our disciplinary application is primarily design. Because sensory experience is foundational in design, research in design is often research in the experience of visual form: how it is made, why it is beautiful, how it functions to help people form meaning. Research from many disciplines sheds light on this experience: neuroscience, cognition, perception, psychology, education, communication, informatics, computer science, library science, linguistics. We welcome articles from these disciplines and more.

Published continuously since 1967, *Visible Language* maintains its policy of having no formal editorial affiliation with any professional organization — this requires the continuing, active cooperation of key investigators and practitioners in all of the disciplines that impinge on the journal's mission as stated above.

Website
http://visiblelanguagejournal.com

Postmaster:
send address changes to:
circulation manager name
Office of Business Affairs
College of Design, Architecture, Art, and Planning
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016

Published tri-annually in January, May and October

SUBSCRIPTION RATES

United States	Individual	Institutional
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1 year	$ 56.00	$ 86.00
2 year	$107.00	$166.00
3 year	$153.00	$246.00

Prepayment is required. Make checks payable to University of Cincinnati *Visible Language* in U.S. currency only, foreign banks need a U.S. correspondent bank.

* Canadian subscriptions include additional postage ($9.00 per year).
**Foreign subscriptions include additional postage ($21.00 per year).

ISSN 0022-2224
Published continuously since 1967.
Index included in last issue of volume year.

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