The Two-Handed Desktop Interface: Are We There Yet?

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ABSTRACT
We argue that today's desktop systems poorly engage the hands of users, and reveal a left-hand bias. Arguments are supported by examples and theory — by juxtaposing the affordances of keyboard/mouse technology with theories of bimanual skill. Scrolling is cited as a task in particularly bad repair. A design improvement is suggested.

Keywords
Bimanual skill, handedness, keyboards, input design

INTRODUCTION
News flash from the year 3000:

> *Anthropologists have completed analyses of a recently discovered artifact, dated to the year 2000. The artifact, apparently, is an early form of computing apparatus, probably operated on a desk with input through a keyboard and pointing device. They conclude that inhabitants from this era were predominantly left-handed.*

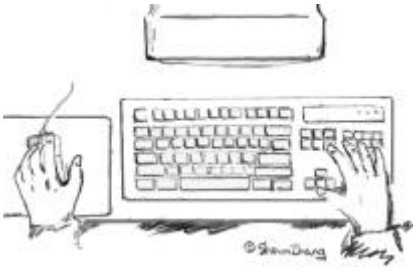
Although not on the scale of archaeologist Howard Carter's 1922 discovery of the tomb of Tutankhamun, this scenario in the year 3000 is offered here as a gentle reality check. In this brief essay, we undertake an analysis of the interaction between the affordances of today's desktop interface and human bimanual skill. The results are surprising.

DESKTOP COMPUTER AFFORDANCES
Affordances are the action possibilities an artifact offers to a user [2]. A keyboard's keys can be pressed, a mouse can be acquired and moved, mouse buttons can be pressed and the wheel can be rotated. These are the *what* of desktop computer affordances. Let's consider the *where*.

Keys are spread across the keyboard, there is a wide space bar along the bottom, and non-alpha keys are in various locations. Although slight variations exist, the 101-style keyboard is most common today. Of concern here are the "power keys", consisting of executive keys (e.g., ENTER) and modifier keys (e.g., SHIFT). On the keyboard's left we find SHIFT, CTRL, ALT, TAB, CAPS LOCK, ESC, while on the right we find no less than 18 power keys: SHIFT, CTRL, ALT, ENTER, BACKSPACE, INSERT, DELETE, HOME, END, PAGE UP, PAGE DOWN, ←, ↑, →, ↓, PRNT SCRN, SCROLL LOCK, and PAUSE. Because SHIFT, CTRL, and ALT are mirrored, they pose no bias and are eliminated from further discussion. Only three keys on the left (ESC, TAB, CAPS LOCK) are without a right-side replica, thus, the numbers are 3 on the left, 15 on the right. The ratio is 1:5.

Clearly, the keyboard is entrenched with a right-side bias. This was fine in the 1970s; however, the emergence of the GUI and point-and-click interfaces in the 1980s changed everything (but not the keyboard, apparently). Most users grasp the mouse in their right hand. A simple observation is that the right hand is busy, and, we argue, overloaded.

Interactions that involve both power-key activation and pointing are exacerbated for right-handed (RH) users: their options are to "reach over" with the left hand (LF), or release the mouse and activate a power key with their RH.



The scenario differs for LH users, however (see right). With this introduction, we shift our discussion to human bimanual skill.

HUMAN SKILL
Humans are not only two-handed—they use their hands differently. Research on the between-hand division of labor in everyday tasks [3] and HCI [1] reveals that most tasks are asymmetric. Typically, the non-preferred (NP) hand leads, sets the frame of reference for the preferred (P) hand, and works at a relatively coarse level. The P hand follows, works within the frame of reference set by the NP hand, and acts at a finer level.

In the example to the right, a right-handed graphic artist is shown sketching the design of a new car. The artist acquires the template with her LH (*NP hand goes first*); the template is manipulated over the

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workspace (*coarse movement, sets frame of reference*). The stylus is acquired in the RH (*P hand follows*) and brought into the vicinity of the template (*works within frame of reference set by NP hand*). Sketching takes place (*P hand makes precise movements*).

Does the desktop interface afford similar interaction? As we argue next, yes, opportunities exist, but they are coincidently attuned to LH users. On the whole, keyboard design is feature-driven. Design changes are incremental — evolutionary, rather than revolutionary. The jumping-off point for change is, unfortunately, the pre-GUI power-key bias noted earlier. It appears little consideration is given of the differentiating roles of P hand and NP hand.

TASK ANALYSIS

In this section we combine earlier points on affordances and human skill in analyzing common GUI tasks. As we shall see, the bimanual skill model is often violated (viz. P hand leads). Faced with the unyielding affordances of the keyboard, users (both LH and RH) naturally discover and adopt strategies of optimization. In short, users find a way to optimize, often in spite of the interface. The path of discovery seems to favor LH users, however. Four examples are cited, as performed by LH users:

Delete: 1st - LH manipulates pointer with mouse, select text (various ways). 2nd - RH presses DELETE with little finger

Select an option in a window (see below): 1st - LH manipulates pointer with mouse, click on option. 2nd - RH presses ENTER (OK button is default)

Click on a link in a browser: 1st - RH navigates to link via PAGE UP and/or PAGE DOWN. 2nd - LH clicks on link via mouse button

Open a file or folder, or launch a program: 1st - LH manipulates pointer with mouse, single click on icon. 2nd - RH presses ENTER (avoids error-prone double-click)

Although other exist, the example tasks are faster for LH users than for RH users. (RH readers may wish to reconsider the examples.) The unifying observation is this:

> *When pointing is juxtaposed with power key activation (excluding SHIFT, ALT, & CONTROL), the desktop interface presents a LH bias.*

Importantly, the tasks are what we do *all the time*. That is, LH users persistently "cash in" on small time savings. This leads to our conclusion that the desktop interface presents a LH bias, and, hence, to this essay's opening quip.

SCROLLING

A striking deficiency in desktop interfaces is scrolling. Although scrolling is an extremely common GUI task, affordances are poor for LH users *and* RH users. This we see as an opportunity for design.

Scrolling is suited to the NP hand, since its relationship with other tasks conforms to the bimanual skill model:

Task	Characteristics
scrolling	• precedes/overlaps other tasks • sets frame of reference • minimal precision needed (coarse)
selecting, editing, drawing, etc.	• follows/overlaps scrolling • works within frame of reference • demands precision (fine)

The wheel mouse puts scrolling in P hand. This is bad for LH users, but it is even worse for RH users, because of the higher demands of the power-key bias noted earlier. Below is a scrolling concept for a LH user. A touch strip or wheel could be used. There are many implementation issues, such as scrolling sensitivity or paging, but space precludes elaboration. Our point is simply that scrolling should be delegated to the non-dominant hand. See also [1].

CONCLUSIONS AND FUTURE DIRECTIONS

In this informal analysis, we examined common GUI tasks and patterns of bimanual skill to show that current desktop systems are biased for left-handed users. In the absence of a detailed functional taxonomy unifying the actions of the P hand and NP hand with system affordances, however, specific design recommendations are premature. Broadly stated, such efforts should seek to tightly couple the hands — supporting sequential, cooperative action — with tasks such as power key activation, pointing, and scrolling.

As a postscript, the keyboard from Xerox *Star* (circa 1981) is shown below [4]. The keyboard includes power keys, such as DELETE and COPY, on the left-hand side.

Would anthropologists from the year 3000 have reached a different conclusion had the archaeologist's dig turned up this system, rather than one from the year 2000?

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