Applied Ergonomics 45 (2014) 917–922

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Task-specific performance effects with different numeric keypad layouts

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ARTICLE INFO

Article history:
Received 23 August 2012
Accepted 13 November 2013

Keywords:
Numeric keypads
Task-specific performance
Interference

ABSTRACT

Two commonly used keypad arrangements are the telephone and calculator layouts. The purpose of this study was to determine if entering different types of numeric information was quicker and more accurate with the telephone or the calculator layout on a computer keyboard numeric keypad. Fifty-seven participants saw a 10-digit numeric stimulus to type with a computer number keypad as quickly and as accurately as possible. Stimuli were presented in either a numerical [1,234,567,890] or phone [(123) 456-7890] format. The results indicated that participants' memory of the layout for the arrangement of keys on a telephone was significantly better than the layout of a calculator. In addition, the results showed that participants were more accurate when entering stimuli using the calculator keypad layout. Critically, participants' response times showed an interaction of stimulus format and keypad layout: participants were specifically slowed when entering numeric stimuli using a telephone keypad layout. Responses made using the middle row of keys were faster and more accurate than responses using the top and bottom row of keys. Implications for keypad design and cell phone usage are discussed.

1. Introduction

1.1. Background

Many daily activities require people to enter numeric information using a keypad. For example, telephones, smart phones, calculators, computers, automated-teller-machines (ATMs), and home alarm systems all have keypads that people frequently use to enter strings of digits. Likewise, there is a wide variety of numerical information that is entered into keypad devices, including phone numbers, account numbers, birthdates, and currency values. Two observations about keypads motivated the current research. First, many people are not explicitly aware that the number keypad layout differs across devices such as telephones and calculators (Rinck, 1999). Second, people typically interact with many of the above devices with conflicting numeric keypad layouts on a daily basis, yet intuitively performance does not seem to show drastic consequences of keypad arrangement inconsistency. Additionally, with more technological devices pervading common human experience, research on layouts of keypads is as relevant today as ever. With hundreds of laptops and telephones, dozens of tablets and other devices on the market, ergonomic keyboard and keypad layout is a concern for buyers and designers.

Despite the frequent use of telephones and calculator/computer keypads, individuals exhibit surprisingly poor memory when explicitly asked to reproduce the layout of numbers on these devices (Fig. 1). For example, Rinck (1999, Experiment 1) tested college students on their ability to correctly place the digits on a blank sheet using their memory for the layout of either a telephone or a calculator. Accuracy for the correct placements of the digits 1 to 9 was 78% for the telephone versus 48% for the calculator layout. That is, approximately one-half of the college students tested could not explicitly recall the location of the digits on a calculator keypad, as presented in Fig. 1. In addition, Rinck found that when participants made errors, especially on the calculator layout, they reversed the layout (for example, entered the layout for numbers on a telephone when they were supposed to enter the layout of a calculator). Jones and Martin (2009) also found relatively low recall for the calculator layout in their sample of college students. Only about 25% of the participants in the control group, which was not provided with any strategies or explicit instructions, reproduced the calculator layout in its entirety with all of the digits in the correct location. In contrast, the same participants reproduced the telephone layout with near-perfect accuracy.

Rinck (1999) provided evidence that there is interference that occurs when accessing the mental representation of keypad

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http://dx.doi.org/10.1016/j.apergo.2013.11.008

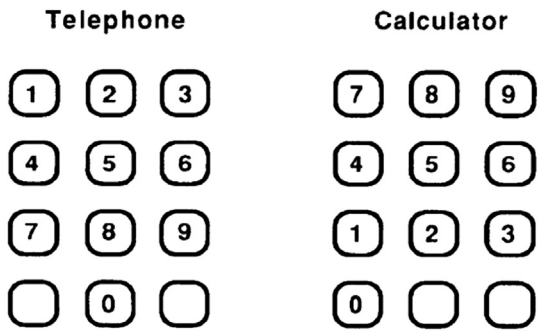

Fig. 1. From "Memory for everyday objects: Where are the digits on numerical keypads?" by Rinck (1999), *Applied Cognitive Psychology*, *13*, p. 330. Copyright 1999 by John Wiley & Sons, Ltd.

layouts. However, in practice most individuals are able to switch between devices with relative ease. For example, consider the many work-related tasks completed by a pharmacy technician. She may spend much of her time at work dialing phone numbers into a phone to call customers to tell them their prescriptions are ready, insurance companies to clarify benefit information, or doctors' offices to verify dosage and medical history. However, she likely also spends a lot of time entering numeric information, including customers' phone numbers and insurance account numbers, into the computer using the keypad (which is arranged like a calculator). Another example of an occupation where the user enters a variety of different numeric information is a ticket agent for an airline. When checking in for a flight at the airport, an airline ticket agent may use the numeric keypad on a desktop keypad (which matches a calculator layout) to enter the passenger's confirmation number, airline rewards number, driver's license identification number, phone number, birthdate, and credit card number. With the advent of alternative telecommunication options, voice-over-internet-protocol users typically use computer numeric keypads to dial telephone numbers. Students working in a research lab often enter various types of numeric information into statistical software packages using the numeric keypad on a desktop computer. Therefore, the purpose of the current research is to determine if entering different types of numeric information is quicker and more accurate with the telephone or the calculator layout.

Previous research on this topic has been inconsistent and may be outdated. Deininger (1960) conducted research at Bell Laboratories testing different potential layouts for new touchtone telephone devices. In one experiment, employees entered random phone numbers on 16 possible different layouts, including the then-current arrangement of adding machines (calculators) and the present-day arrangement of telephones (not currently in use). Deininger reported that participants were slightly faster using the telephone (4.92 s) versus the calculator (5.08 s) layout, but no accuracy information was reported.

Conrad and Hull (1968) tested participants with no experience using a touchtone telephone or adding machine, and examined their performance at entering random 8-digit strings. The group of participants that used the telephone layout was more accurate than the group that used the calculator layout, although the groups did not statistically differ in the speed of correct digit entry.

These results correspond with research assessing users' preferences for potential keypad layouts. The majority of naïve and experienced participants indicate a preference for the telephone versus the calculator layout (Lutz and Chapanis, 1955). This preference is especially strong when participants are asked to imagine scenarios in which they would enter telephone numbers, but somewhat surprisingly, the preference for the telephone layout versus the calculator layout also applies to other tasks such as entering personal identification numbers and single digits (Straub and Granaas, 1993). It should be noted that much of this research was conducted at a time when computer keypad usage was rare. Indeed, prior to the 1980s, personal computers were not commonly used in homes and businesses, thus limiting people's exposure to the calculator keypad layout relative to today.

Marteniuk et al. (1996) tested college students on their ability to enter four-digit strings, seven-digit strings, and seven-digit telephone numbers using either a calculator or a telephone keypad layout. Marteniuk et al. focused on the effect of the placement of the zero-digit key (above or below the other keys) across keypad layout types. Although Marteniuk et al. concluded, against their predictions, that "no interactions between the task and the keypad arrangement were found" (p. 325), in the article they only reported the separate analyses conducted for the different stimulus formats. Without the benefit of significance testing, visual inspection of the data indicates that participants were faster and more accurate entering telephone numbers compared to seven-digit strings without telephone formatting. However, they reported no significant effects of keypad layout on either accuracy or the total amount of time to enter the string of digits.

The three studies just discussed provide contradictory results. The conclusion from two studies (Conrad and Hull, 1968; Deininger, 1960) is that there is a slight advantage for the telephone layout no matter if the user is entering telephone or numeric information. However, Marteniuk et al. (1996) found no significant effects of keypad layout. The participants in Deininger (1960) and Conrad and Hull (1968) are somewhat unique in that they participated in the research with no history or exposure to the telephone layout, due in part to limited availability of technology in the 1960s. In contrast, in today's society in many developed countries, virtually all young adults have extensive exposure and practice using telephones and calculators. Thus, the participants in Marteniuk et al. (1996) may not have shown an advantage of either type of keypad arrangement because of their experience with both telephone and calculator layouts that the participants in the earlier studies did not have.

1.2. Current research

The current study combines elements of both Rinck (1999, Experiment 1) and Marteniuk et al. (1996), but attempted to expand upon their studies in multiple ways. First, in contrast to Rinck (1999), we tested participants' knowledge of telephone and calculator layouts using a within-subjects design. Additionally, a potentially important aspect of the stimuli that Marteniuk et al. used was that the numeric stimuli were presented as one continuous sequence of seven digits (e.g., 1947294), whereas the phone numbers were presented with a hyphen (e.g., 396–8142). Because of concerns that the phone stimuli were easier for participants in Marteniuk et al. to chunk in short-term memory, in the current research we added commas to the numeric digit strings to provide comparable chunks for participants to utilize. In addition, we tested all participants on their ability to enter all 10 digits on the keypad on each trial, whether as a numerical [1,234,567,890] or phone [(123) 456-7890] presentation. This decision provided two advantages over Marteniuk et al. First, by including all possible digits once in each stimulus, we controlled across trials for effects of key position upon performance (see below). Second, with the widespread use of cell phones, many dialed numbers today in the United States are ten digits, and thus the current stimuli may be more similar to the numbers dialed in daily telephone usage. Finally, in the current research we tested over twice as many participants and administered twice as many trials per condition than Marteniuk et al., because some trends that were not statistically significant in