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BSI Standards Publication

Ergonomics of human-system interaction

Part 420: Selection of physical input devices
(ISO 9241-420:2011)

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National foreword

This British Standard is the UK implementation of EN ISO 9241-420:2011. Together with BS EN ISO 9241-400:2007, PD CEN ISO/TS 9241-411:2014, and BS EN ISO 9241-410:2008+A1:2012, it supersedes BS EN ISO 9241-4:1998 and BS EN ISO 9241-9:2000, which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PH/9, Applied ergonomics.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Ergonomie de l'interaction homme-système - Partie 420:
Sélection des dispositifs d'entrée physiques (ISO 9241-
420:2011)

Ergonomie der Mensch-System-Interaktion - Teil 420:
Auswahlverfahren für physikalische Eingabegeräte (ISO
9241-420:2011)

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Foreword

This document (EN ISO 9241-420:2011) has been prepared by Technical Committee ISO/TC 159 "Ergonomics" in collaboration with Technical Committee CEN/TC 122 "Ergonomics" the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2012, and conflicting national standards shall be withdrawn at the latest by January 2012.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9241-420 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

This first edition of ISO 9241-420, together with ISO 9241-400, ISO 9241-410 and ISO/TS 9241-411, partially replaces ISO 9241-4 and ISO 9241-9, technically revised as follows:

- terms and definitions from ISO 9241-4 and ISO 9241-9 have been transferred to ISO 9241-400;
- guiding principles, collected in ISO 9241-400, have been incorporated and unified so that they correspond to the scope of the new ISO 9241 series;
- test methods taken from ISO 9241-4 and ISO 9241-9 have been reviewed and amended and new test methods introduced and collected in annexes for greater convenience.

ISO 9241 consists of the following parts, under the general title *Ergonomic requirements for office work with visual display terminals (VDTs)*:

- *Part 1: General introduction*
- *Part 2: Guidance on task requirements*
- *Part 4: Keyboard requirements*
- *Part 5: Workstation layout and postural requirements*
- *Part 6: Guidance on the work environment*
- *Part 9: Requirements for non-keyboard input devices*
- *Part 11: Guidance on usability*
- *Part 12: Presentation of information*
- *Part 13: User guidance*
- *Part 14: Menu dialogues*
- *Part 15: Command dialogues*

— *Part 16: Direct manipulation dialogues*

— *Part 17: Form filling dialogues*

ISO 9241 also consists of the following parts, under the general title *Ergonomics of human-system interaction*:

— *Part 20: Accessibility guidelines for information/communication technology (ICT) equipment and services*

— *Part 100: Introduction to standards related to software ergonomics* [Technical Report]

— *Part 110: Dialogue principles*

— *Part 129: Guidance on software individualization*

— *Part 143: Forms*

— *Part 151: Guidance on World Wide Web user interfaces*

— *Part 171: Guidance on software accessibility*

— *Part 210: Human-centred design for interactive systems*

— *Part 300: Introduction to electronic visual display requirements*

— *Part 302: Terminology for electronic visual displays*

— *Part 303: Requirements for electronic visual displays*

— *Part 304: User performance test methods for electronic visual displays*

— *Part 305: Optical laboratory test methods for electronic visual displays*

— *Part 306: Field assessment methods for electronic visual displays*

— *Part 307: Analysis and compliance test methods for electronic visual displays*

— *Part 308: Surface-conduction electron-emitter displays (SED)* [Technical Report]

— *Part 309: Organic light-emitting diode (OLED) displays* [Technical Report]

— *Part 310: Visibility, aesthetics and ergonomics of pixel defects* [Technical Report]

— *Part 400: Principles and requirements for physical input devices*

— *Part 410: Design criteria for physical input devices*

— *Part 411: Evaluation methods for the design of physical input devices* [Technical Specification]

— *Part 420: Selection of physical input devices*

— *Part 910: Framework for tactile and haptic interaction*

— *Part 920: Guidance on tactile and haptic interactions*

The following parts are under preparation:

— *Part 143: Form-based dialogues*

— *Part 154: Interactive voice response (IVR) applications*

Human-centred design and evaluation methods, optical characteristics of autostereoscopic displays, and requirements, analysis and compliance test methods for the reduction of photosensitive seizures are to form the subjects of future parts 230, 330 and 391.

Introduction

Input devices provide the means for users to enter data into interactive systems. Generally speaking, an input device is a sensor that can detect changes in user behaviour (gestures, moving fingers, etc.) and transform them into signals to be interpreted by the interactive system.

This part of ISO 9241 gives guidance for selecting products on the basis of the relevant properties of the input devices, as outlined in ISO 9241-400, and the design criteria for products, as given in ISO 9241-410. It also includes test and evaluation methods for use at the workplace level. To accelerate the future development of test and evaluation methods, these are treated in separate annexes according to the maturity of the test procedure.

This part of ISO 9241 includes test and evaluation methods for application by user organizations. These methods can also be applied by test houses.

Ergonomics of human-system interaction —

Part 420: Selection of physical input devices

1 Scope

This part of ISO 9241 provides guidance for the selection of input devices for interactive systems, based on ergonomic factors, considering the limitations and capabilities of users and the specific tasks and context of use. It describes methods for selecting a device or a combination of devices for the task at hand. It can also be used for evaluating the acceptability of trade-offs under the existing conditions.

The target users of this part of ISO 9241 are user organizations and systems integrators who tailor systems for a given context of use.

It is applicable to the following input devices: keyboards, mice, pucks, joysticks, trackballs, trackpads, tablets and overlays, touch-sensitive screens, styli and light pens. It does not specify design requirements or give recommendations for those devices.

NOTE 1 The selection guidance has been developed for the single-finger use of touchpads. Touchpads that allow the use of more fingers do exist; however, this part of ISO 9241 does not offer any guidance on their selection.

NOTE 2 The only physical component of a speech-recognition system is a microphone. Without proper knowledge of the context of use it is not possible to give guidance for selection.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9241-11, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 11: Guidance on usability*

ISO 9241-400, *Ergonomics of human-system interaction — Part 400: Principles and requirements for physical input devices*

ISO 9241-410, *Ergonomics of human-system interaction — Part 410: Design criteria for physical input devices*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9241-400 and ISO 9241-410 and the following apply.

3.1

appropriateness

application of the concept of usability on entities that are combined for a specific purpose

EXAMPLE 1 Achieving a certain level of usability for users with special needs or for uses where no single device can achieve the level of usability required for a certain task.

EXAMPLE 2 Achieving a certain level of usability for text input and dragging by a combination of a keyboard and a tablet.

NOTE See also ISO 9241-400 and ISO 9241-410.

3.2

cursor

visual indication of where the user interaction via keyboard (or equivalent input device) will occur

[ISO 9241-400:2007, 5.3.2]

3.3

dragging

dragging and dropping

moving one (or more) objects on a display by translating it along a path determined by a pointer

[ISO 9241-400:2007, 3.9.1]

3.4

accessibility

⟨interactive system⟩ usability of a product, service, environment or facility by people with the widest range of capabilities

NOTE 1 The concept of accessibility addresses the full range of user capabilities and is not limited to users who are formally recognized as having a disability.

NOTE 2 The usability-orientated concept of accessibility aims to achieve levels of effectiveness, efficiency and satisfaction that are as high as possible considering the specified context of use, while paying particular attention to the full range of capabilities within the user population.

[ISO 9241-20:2008, 3.1]

3.5

effectiveness

accuracy and completeness with which users achieve specified goals

[ISO 9241-11:1998, 3.2]

3.6

efficiency

resources expended in relation to the accuracy and completeness with which users achieve goals

[ISO 9241-11:1998, 3.3]

3.7

home row

row of the keyboard to which the fingers typically return between keystrokes

See Figure 1.

NOTE On the typical keyboard, the home row is row C as defined by ISO/IEC 9995-1:1994 in the alphanumeric section as well as in the numeric section.

[ISO 9241-400:2007, 3.6.1]

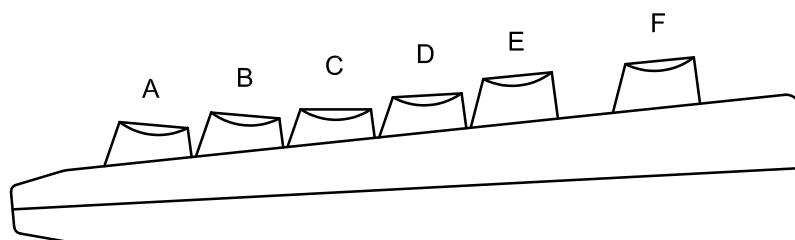


Figure 1 — Typical keyboard — Home row

3.8 home row height

h

height from the centre of the strike surface of an unactuated key in the home row to the support surface

See Figure 2.

[ISO 9241-400:2007, 3.6.2]

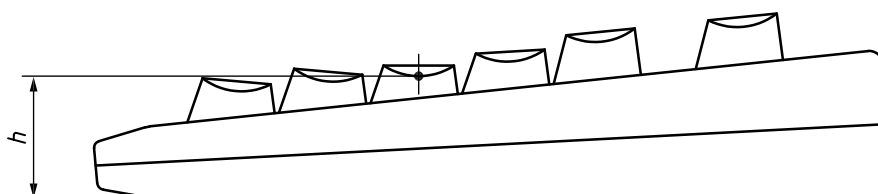


Figure 2 — Typical keyboard — Home row height

3.9 index of difficulty

I_D

measure of the user precision required in a task

NOTE The index of difficulty, I_D , is measured in bits, and is calculated for selection, pointing, or dragging tasks by

$$I_D = \log_2 \frac{d + w}{w} \quad (1)$$

and for tracing tasks by

$$I_D = \frac{d}{w} \quad (2)$$

where

d is the distance of movement to the target;

w is the target width of the displayed target along the approach axis for selection, pointing or dragging tasks, and perpendicular for tracing tasks.

[ISO 9241-410:2008, 3.12]

3.10 input device

user-controlled device that transmits information to a system

[ISO 9241-400:2007, 3.6.3]

3.11

intended user population

group of human beings for which a product or a workstation is designed

EXAMPLE Male and female workers of Southeast Asian origin aged between 45 and 65 years.

[ISO 9241-400:2007, 3.7.7]

3.12

joystick

lever mounted in a fixed base used to control the movement of objects displayed on a screen

NOTE See Figure 3.

[ISO 9241-400:2007, 3.6.4]

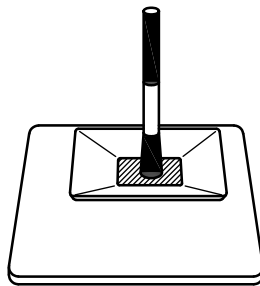


Figure 3 — Side view of example joystick

3.12.1

displacement joystick

joystick with a lever that tilts in the direction of applied force from a home position moving the display pointer in proportion to the displacement distance

[ISO 9241-400:2007, 3.6.4.1]

3.12.2

isometric joystick

joystick where the input depends on the force exerted rather than the position of the control

[ISO 9241-400:2007, 3.6.4.2]

3.13

keyboard layout

spatial allocation of keys on a keyboard

[ISO 9241-400:2007, 3.6.9]

3.14

keyboard profile

geometric (i.e. flat, stepped, sloped, dished or sculptured) configuration of the top of the keys

[ISO 9241-400:2007, 3.6.5]

3.14.1

dished profile keyboard

keyboard in which the side profile of the keys resembles a continuous concave curve

NOTE See Figure 4.

[ISO 9241-400:2007, 3.6.5.1]

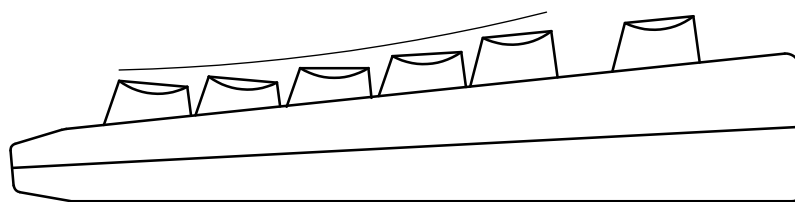


Figure 4 — Example of dished profile keyboard

3.14.2

flat profile keyboard

keyboard that has a zero slope with the front at the same height as the back when placed on a flat work surface

NOTE See Figure 5.

[ISO 9241-400:2007, 3.6.5.2]

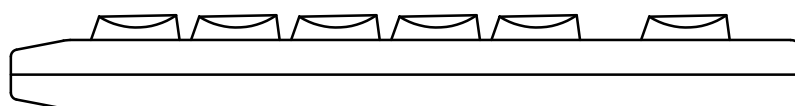


Figure 5 — Example of flat profile keyboard

3.14.3

keyboard slope

α

angle between the plane of the key top surfaces (P-P) and the horizontal surface (H-H) as measured across row A-E using the notation of ISO 9995-1

See Figure 6.

NOTE For keyboards without an E row, rows B to D are used.

[ISO 9241-400:2007, 3.6.5.3]

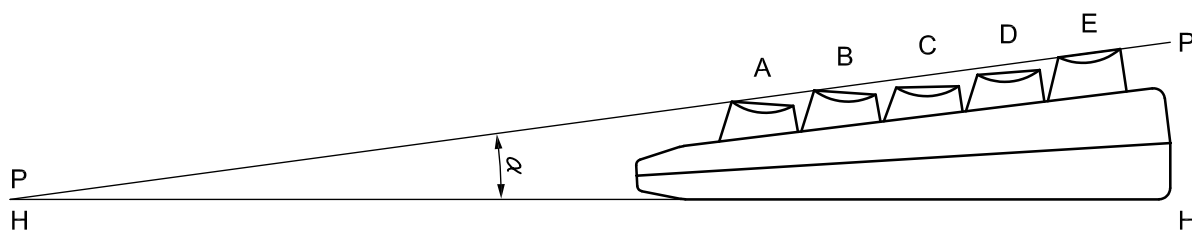


Figure 6 — Keyboard slope

3.14.4

sculptured profile keyboard

keyboard in which the side view of the keytops is shaped in other than a straight line

NOTE See Figure 7.

[ISO 9241-400:2007, 3.6.5.4]

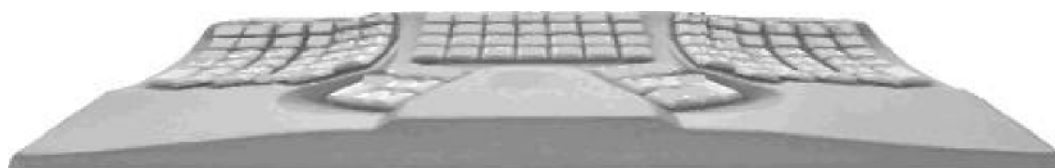


Figure 7 — Example of sculptured profile keyboard

3.14.5

stepped profile keyboard

keyboard in which the top of each row of keys is parallel to the work surface but at a different height from the work surface

NOTE 1 See Figure 8.

NOTE 2 Adapted from ISO 9241-400:2007, definition 3.6.5.5.

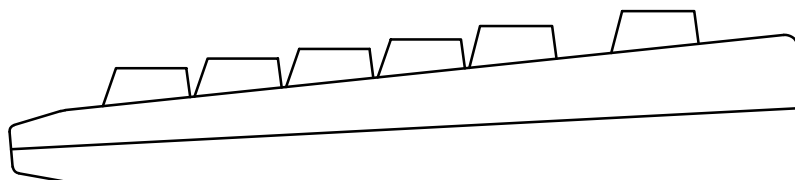


Figure 8 — Example of stepped profile keyboard

3.15

key displacement

key movement from its rest position to its fully depressed position

[ISO 9241-400:2007, 3.6.6]

3.16

key force

force required to displace a key to a specified position

[ISO 9241-400:2007, 3.6.7]

3.17

key roll over

ability of a keyboard to register the correct order of activation of a set of keys

[ISO 9241-400:2007, 3.6.8]

3.18

light pen

light-sensitive input device that, when pointed onto a specific location on a display, identifies its position to the system

NOTE See Figure 9.

[ISO 9241-400:2007, 3.6.10]

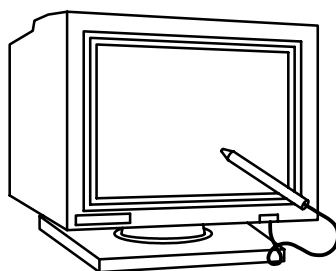


Figure 9 — Example of light pen against display

3.19

mouse

computer input device having one or more buttons and capable of two-dimensional rolling motion which can drive a pointer on the display and performs a variety of selection options or commands

NOTE Adapted from ISO 9241-400:2007, definition 3.6.11.

3.20

numeric keypad

array of keys in the numeric section to which are allocated the ten digits 0 to 9 and the decimal separator

[ISO 9241-400:2007, 3.6.12]

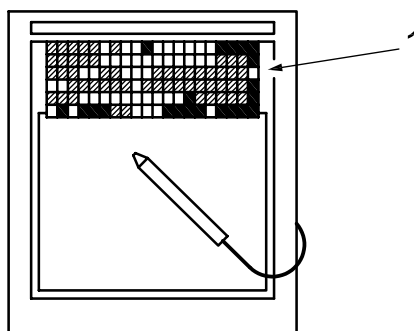
3.21

overlay

thin template on the surface of a tablet used to indicate the graphic functions available to the user

NOTE See Figure 10.

[ISO 9241-400:2007, 3.6.13]



Key

1 graphic overlay

Figure 10 — Top view of example table with graphic overlay

3.22

palm rest

surface supporting the palm of the hand (when using an input device) for a keyboard platform placed in front of the keyboard or embedded in the keyboard on which the operator may place the palms of the hands

[ISO 9241-400:2007, 3.6.14]

3.23

pointer

symbol on a display, which indicates input or selection position whose movement is controlled by an input device

[ISO 9241-400:2007, 3.6.15]

3.24

pointing

operation with a graphic user interface in which an input device is used to move a small display image (such as a pointer) to a specific location on the display

[ISO 9241-400:2007, 3.9.2]

3.25
puck

hand-held device similar to a mouse but with a reticle view port and that is typically used with a digitising tablet

NOTE See Figure 11.

[ISO 9241-400:2007, 3.6.16]

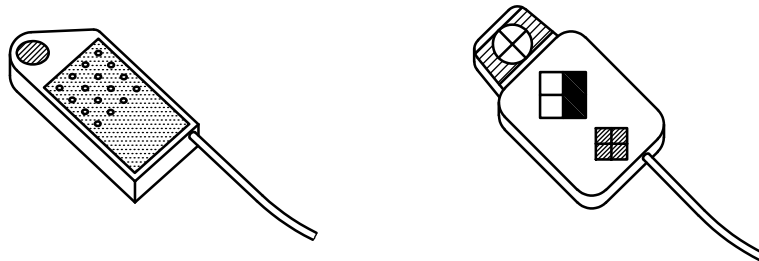


Figure 11 — Top view examples of two types of puck

3.26
quality

degree to which a set of inherent characteristics fulfils requirements

NOTE 1 The term “quality” can be used with adjectives such as poor, good or excellent.

NOTE 2 “Inherent”, as opposed to “assigned”, means existing in something, especially as a permanent characteristic.

[ISO 9000:2005, 3.1.1]

3.27
ramp action

kinaesthetic sensation during key actuation in which the force required to actuate the key increases as the key is displaced

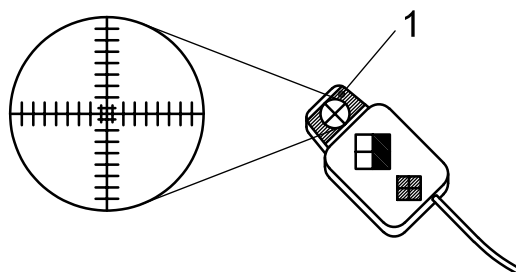
[ISO 9241-400:2007, 3.6.17]

3.28
reticle

orthogonal lines in the lens of a puck used to visually align the puck to an image

NOTE See Figure 12.

[ISO 9241-400:2007, 3.6.18]



Key

1 reticle

Figure 12 — Top view of example puck with reticle

3.29

satisfaction

freedom from discomfort, and positive attitudes towards the use of the product

[ISO 9241-11:1998, 3.4]

3.30

section

⟨keyboard⟩ part of a keyboard

EXAMPLE Alphanumeric section, editing section, function section or numeric section.

[ISO 9241-400:2007, 3.6.19]

3.31

selecting

choosing one or more items on a display

[ISO 9241-400:2007, 3.9.3]

3.32

selector button

actuator located on an input device

[ISO 9241-400:2007, 3.6.20]

3.33

snap action

sudden drop in force required to further displace a key

[ISO 9241-400:2007, 3.6.21]

3.34

strike surface

area on the top surface of the key, which the finger contacts during key actuation

[ISO 9241-400:2007, 3.6.22]

3.35

stylus

pen-shaped pointing device which, when touched to a display or graphics tablet, can be used to draw images on a display or select displayed objects, typically by depressing the stylus tip or actuating a button located along the side of the stylus

NOTE See Figure 13.

[ISO 9241-400:2007, 3.6.23]

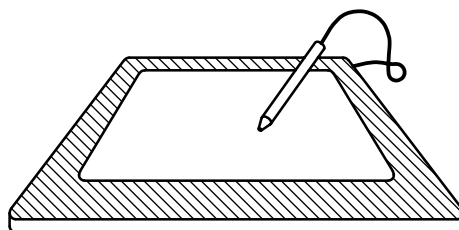


Figure 13 — Side view example of stylus over graphics tablet

3.36

tablet

special flat surface with an input device (such as a stylus or puck) for selection, drawing, or indicating the position, of images to be displayed

[ISO 9241-400:2007, 3.6.24]

3.37

tactile indicator keys

keys in the home row which contain a tactile aid for recentring the hands

[ISO 9241-400:2007, 3.6.25]

3.38

task primitive

fundamental action (such as pointing, selecting and dragging) associated with using a non-keyboard input device

NOTE User tasks contain a mix of task primitives.

[ISO 9241-400:2007, 3.9.4]

3.39

tracing

following the outline of an image by moving the pointer or input device over the lines or shape of an image

[ISO 9241-400:2007, 3.9.5]

3.40

trackball

ball in a fixed housing that can be rolled in any direction by the fingers to control pointer movement and that often has adjacent buttons

NOTE See Figure 14.

[ISO 9241-400:2007, 3.6.26]

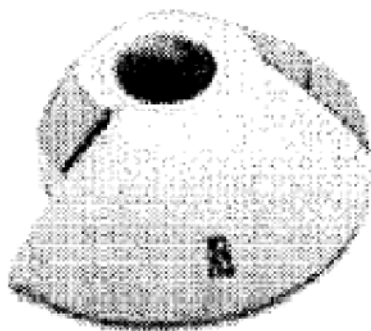


Figure 14 — Example of top view of trackball device with buttons

3.41

touch sensitive screen

TSS

input device that produces a position and selection input signal from a finger touching, lifting off, or moving across a display

[ISO 9241-400:2007, 3.6.27]

3.42

usability

extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

[ISO 9241-11:1998, 3.1]

3.43

workstation

combination and spatial arrangement of work equipment, surrounded by the work environment under the conditions imposed by the work tasks

[ISO 6385:2004, 2.12]

NOTE This is a general definition of workstation and is different from the definition of the same term given in ISO 9241-5, which is specific to VDT work.

4 Procedures for selecting equipment — General considerations

4.1 Rationale

4.1.1 Concept

Selection procedures can enable a suitable tool or combination of tools for a given task, environment or user to be found. The procedures of this part of ISO 9241 are based on the concept of usability as defined and described in ISO 9241-11. This concept states that a product has no inherent usability, but one in a specified context of use, for specified goals and specified users. Thus, a product may be designed under the assumption of certain conditions for its use (intended context of use) whereas the conditions for the real use may differ from them (actual context of use). For example, laptop computers designed for mobile use may be used in office environments and office equipment may be used in homes. For the actual use, the usability of a device can differ widely from that achievable under the conditions that the designer had assumed.

In order to differentiate the abilities of a device during actual use from its usability, ISO 9241-400 uses the concept of appropriateness, i.e. the usability under the specific conditions of the practical use. For example, the effectiveness of a mouse may suffer severely if utilised together with a keyboard that occupies the space where the mouse should be located for optimum use. Its operation may also be less satisfactory for the user if there is no proper space on the workstation.

4.1.2 Assessing devices under practical conditions

An ergonomic selection procedure differs in principle from the ergonomic design of a device in that the selection considers the actual conditions, whereas the design takes into account the intended context of use. In ideal cases, the designer anticipates the actual conditions by appropriate evaluation of the likely conditions for the use of the product. However, in general, either the actual context of use is different from the anticipated context or a device has to be used for a task outside its intended context of use because of other overriding considerations. There are at least three reasons for applying selection procedures for input devices:

- selection of those input devices that fit best the task(s) of the user and the software that is being used;
- composing a set of devices that make up the best combination of devices for the actual context of use;
- selection of those input devices that are optimal for the physical conditions in the actual context of use.

In general, most devices are designed in consideration of their use in isolation and under reasonable circumstances. For example, a mouse may be designed for manipulating images, for a task for which the services offered by the device will suffice most of the time. The other extreme is using a keyboard for entering text only, similar to the use of a typewriter. Most tasks, however, lie between these extremes and require

concurrent use of both devices, but to a different extent. Since types of keyboards differ widely, as pointing devices do to even a greater extent, an optimum pairing of two devices may differ from task to task. In addition, considering relevant characteristics of the environment (e.g. available space, stability, surface colour and texture) can affect the solution considerably.

From the point of view of the concept of usability, the user should first achieve relevant goals required by the task, e.g. accurate pointing of small objects (effectiveness). Combinations of devices that allow achievement of goals may require different amounts of resources, e.g. single-handed input versus two-handed input, or three-finger grip instead of pressing with a single finger (efficiency). And combinations achieving the same level of effectiveness and efficiency may still differ in the workload they cause for the user or distract him or her through their features. This may lead to good acceptance or to rejection, depending on the satisfaction of user needs (satisfaction).

Following the usability concept, the evaluation of an entity, e.g. a keyboard or software, includes three measures: effectiveness, efficiency and satisfaction. Instead of a formal evaluation of the usability of a product, users of this part of ISO 9241 may choose any of these measures, depending on the practical question. For example, in some cases the relevant question can be whether a device under consideration helps achieve the goals of the specific use. In this case, evaluation of the effectiveness, i.e. the accuracy and completeness with which users achieve specified goals, and describing the performance that is achieved using that entity, may suffice.

Since different tools can help achieve the same performance but require a different level of effort for this purpose, the second measure included in the concept, the efficiency, i.e. resources expended in relation to the accuracy and completeness with which users achieve goals, is relevant for identifying an effort/benefit ratio for the use of an entity. The term *resource* can include different items, e.g. time spent on the task, muscular effort by a user, number of users required or cost. Since the entities to be evaluated can be very different, the concept does not specify measures for efficiency. In the case of input devices, efficiency can be measured by the time needed to accomplish the task and the effort for the user (e.g. musculoskeletal load).

Products that can be used effectively and efficiently are not necessarily accepted by the users if they fail to fully satisfy their needs. The last measure of the concept, satisfaction, helps evaluate the degree to which the needs of users are satisfied.

For the utilization of graphical user interfaces, the oldest input device, the keyboard, often is combined with at least one pointing device. Depending on the functionality required for a certain task, different pointing devices may be usable, nevertheless to a different degree depending on the design of the specific device. When used together with a keyboard, the usability of a certain pointing device may be degraded, and, in addition, the use of the pointing device may hamper the operation of the keyboard.

A variety of reasons may exist that reduce the usability of a device under practical conditions, but there are also many instances for improving it. The usability of any device will depend on the conditions of use. In some cases a combination of devices may offer a more usable solution than either device on its own. The most important condition under which the usability of an input device is improved can be the use of a second device that enables other means of input, thereby also improving accessibility for people who may not be able to use the first device because of disability. The additional device can add new functionality, but it also can enhance existing functionality through synergy. This is the case when the additional device can help to refine one or more functions of the device under consideration.

Thus, there are at least three reasons for applying selection procedures for input devices: a concurrent use of different devices by the same user, the use of a device outside its intended context of use, and the use of a device for purposes for which it has not been designed.

4.1.3 Determining usability of devices for specific user populations

Only few technical products are likely to be usable for all human beings to the same extent and function in the same manner under all circumstances. In general, a product is designed to fully satisfy the needs of a certain user population, the target user or the intended user population (see ISO 9241-5). In many cases, users other than the target user may be able to use a well-designed product, but their needs will be satisfied to a lesser extent (e.g. "secondary users" according to ISO 9241-11). The extent to which a given set of needs are met is

generally defined as being “fit for purpose”. Versatile products may be fit for a variety of user populations or uses. A general-purpose design intends to be fit for an unlimited user population. But even then, users may experience problems using the device for a number of reasons.

The concept of accessibility in ergonomics takes into account that some users may not be able to use a device as intended, temporarily or permanently. This may happen due either to a permanent disability of the user (e.g. impaired motility of the fingers) or as a result of the momentary situation (e.g. one hand being employed for another task). In such situations, the input device(s) at hand may not suffice for a certain task because it requires a higher degree of effectiveness, or the efficiency achievable with the current tool is lower than that required by the task. Accessibility will depend in many cases on flexibility and adaptability in the selection of appropriate input devices. If this is not practical, then it should be possible to use an assistive technology with the system.

Ergonomic selection methods can help determine whether the user can achieve the required level of effectiveness and efficiency with a given tool or combination of tools in a satisfactory manner or whether another type of equipment is needed.

4.2 Objectives for selection procedures

The simplest objective for applying a selection procedure is to determine whether a device is suitable for the intended use (fit for purpose). In this case, one would check whether the intended context of use matches the actual context of use.

Other objectives for user organizations to apply selection procedures may be, for example:

- comparing devices of the same kind for a given context of use (“Brand A” mouse versus “Brand B” mouse if used together with a standard keyboard);
- testing the acceptability of a given device for a task not covered by the intended context of use (e.g. keyboard as a pointing device);
- determining the minimum quality of an input device (e.g. optimum size of a tablet for a required resolution) for a given task;
- determining the acceptability of a replacement (e.g. replacing a trackball by a trackpad or vice versa);
- determining workplace requirements for a given set of work equipment (e.g. size and shape of support surfaces for working with paper documents and two different input devices);
- determining the correct setup of input devices for a given context of use (e.g. driver settings for a device designed for stationary use inside a vehicle).

5 Performance criterion

An input device or a combination of input devices shall be usable for the task at hand, i.e. the actual user shall achieve a satisfactory level of performance on the given task and maintain an acceptable level of effort and satisfaction.

NOTE A satisfactory level of performance is determined by the user organization.

If completion of the task requires the use of more than one physical device, then all required physical devices should be a common metric or metrics for determining the appropriateness as a single unit, i.e. the usability of the combination.

6 Methods and aids for selection of devices

6.1 Task analysis

A simple analysis of the overall task of the user at a given workstation should precede the selection procedure. The depth to which a task analysis should be performed and the properties considered are dependent on the kind of input device and the task. This analysis should help provide the following information:

- task primitives to be supported by the equipment;
- critical task primitive(s) with overriding importance (e.g. character input);
- rank order of the relevance of task primitives for the given context of use;
- relevant restrictions for available support surfaces (size, quality, arrangement);
- mutual exclusion effects (e.g. if two concurrent devices need to be positioned within the same space in the reach envelope);
- required level of effectiveness (e.g. the minimum size of screen area to be accessed by a pointing device is less than 4 pixels);
- required level of efficiency (e.g. selecting and dragging an object using one finger only).

6.2 Selection based on product description

ISO 9241-410 provides lists of the ergonomic features of input devices. The tables given in Annex H are designed to enable the checking of device features where the product description conforms to ISO 9241-410.

In accordance with ISO 9241-410, the relevant information, except for the properties related to the appropriateness for the specific use, shall be included in the documentation.

6.3 User tests

In cases where the product description does not provide the user organization with sufficient information, user tests may help in the selection of the appropriate device. User testing is generally recommended, especially when considering usability for the wider population of characteristics and capabilities.

Occasions when user tests can be warranted include the following:

- utilizing a given device with others that have not been designed for concurrent use (e.g. in the case of mutual exclusion);
- selecting drivers or settings for a given device under a new context of use (subdividing a tablet into smaller zones to reduce postural problems for smaller persons, selecting mouse settings for unstable support surfaces, etc.);
- testing alternative arrangements of work equipment;
- selecting alternatives of the same type of device;
- testing for a critical task primitive to select a dedicated device.

The user tests introduced in this part of ISO 9241 are not equivalent to the laboratory test methods described in ISO/TS 9241-411. However, they may indicate that a more elaborate analysis could be helpful for a given context of use.

In addition to objective user testing, the level of satisfaction with the available or recommended input devices could also be assessed through interviews or questionnaires (see Annex D).

6.4 Selection based on dominant task primitive(s) with overriding importance

Although any input device can also be utilised for tasks for which it has not been designed (e.g. a keyboard for pointing), each type of input device treated in this part of ISO 9241 has certain strengths and weaknesses in the consideration of task primitives.

The task primitives specifically defined by ISO 9241-400 are code entry (alphanumeric input), pointing, dragging, selecting and tracing.

The task primitive pointing may be considered in two dimensions, speed and accuracy, because, for some real tasks, the accuracy plays the overriding role, e.g. for creating drawings, whereas in other cases the speed or speed and accuracy can be of the highest importance. For the purposes of this part of ISO 9241, "pointing" is considered in two ways: accurate and rapid.

For some tasks, free-hand input may be considered as an aspect although it is a mixture of some task primitives. The same is true for scrolling, i.e. moving the point of focus through an image that is bigger than the display area.

The selection in consideration of the task primitive with overriding importance can be made using Figure 15.

NOTE Figures 15 and 16, and Tables 1 and 2, apply to users without special needs. For other user populations, Figures 15 and 16 may have to be modified in consideration of the capabilities of that user population.

	Rapid pointing	Accurate pointing	Selecting	Dragging	Tracing	Free-hand input	Alphanumeric input
Keyboard	□□□	□□□	■□□	□□□	□□□	□□□	■ ■ ■
Mouse	■ ■ ■	■ ■ □	■ ■ ■	■ ■ ■	■ □ □	■ ■ □	□ □ □
Tablet with puck	■ ■ □	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ □	■ □ □
Joystick	■ □ □	■ ■ □	■ ■ □	■ □ □	■ □ □	■ □ □	□ □ □
Trackball	■ ■ □	■ ■ ■	■ ■ ■	■ □ □	■ □ □	■ □ □	□ □ □
Touchpad	■ ■ □	■ ■ □	■ ■ □	■ □ □	■ □ □	■ □ □	□ □ □
Tablet with stylus	■ ■ □	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ □ □
Light pen	■ ■ ■	■ ■ □	■ ■ ■	■ □ □	■ □ □	■ ■ □	■ □ □
Touch screen	■ ■ ■	■ □ □	■ ■ □	■ □ □	■ □ □	■ □ □	■ □ □

Usability

□ □ □ low

■ □ □ low — medium

■ ■ □ medium

■ ■ ■ high

Figure 15 — Overall usability of types of input devices in consideration of task principles and relevant aspects

Table 1 — Overall usability of types of input devices in consideration of task principles and relevant aspects

	Rapid pointing	Accurate pointing	Selecting	Dragging	Tracing	Free-hand input	Alphanumeric input
Keyboard	L	L	LM	L	L	L	H
Mouse	H	M	H	H	LM	M	L
Tablet with puck	H	H	H	H	H	M	M
Joystick	LM	M	M	LM	LM	LM	L
Trackball	M	H	H	LM	LM	LM	L
Touchpad	M	M	M	LM	LM	LM	L
Tablet with stylus	H	H	H	H	H	H	M
Light pen	H	M	H	LM	LM	M	M
Touch screen	H	LM	M	LM	LM	M	M

The structogram shown in Figure 16 for selecting the correct device depicts the decision path for selecting a device. In the case where “tracing” is the overriding task primitive, the tablet with stylus or puck is shown as the best choice.

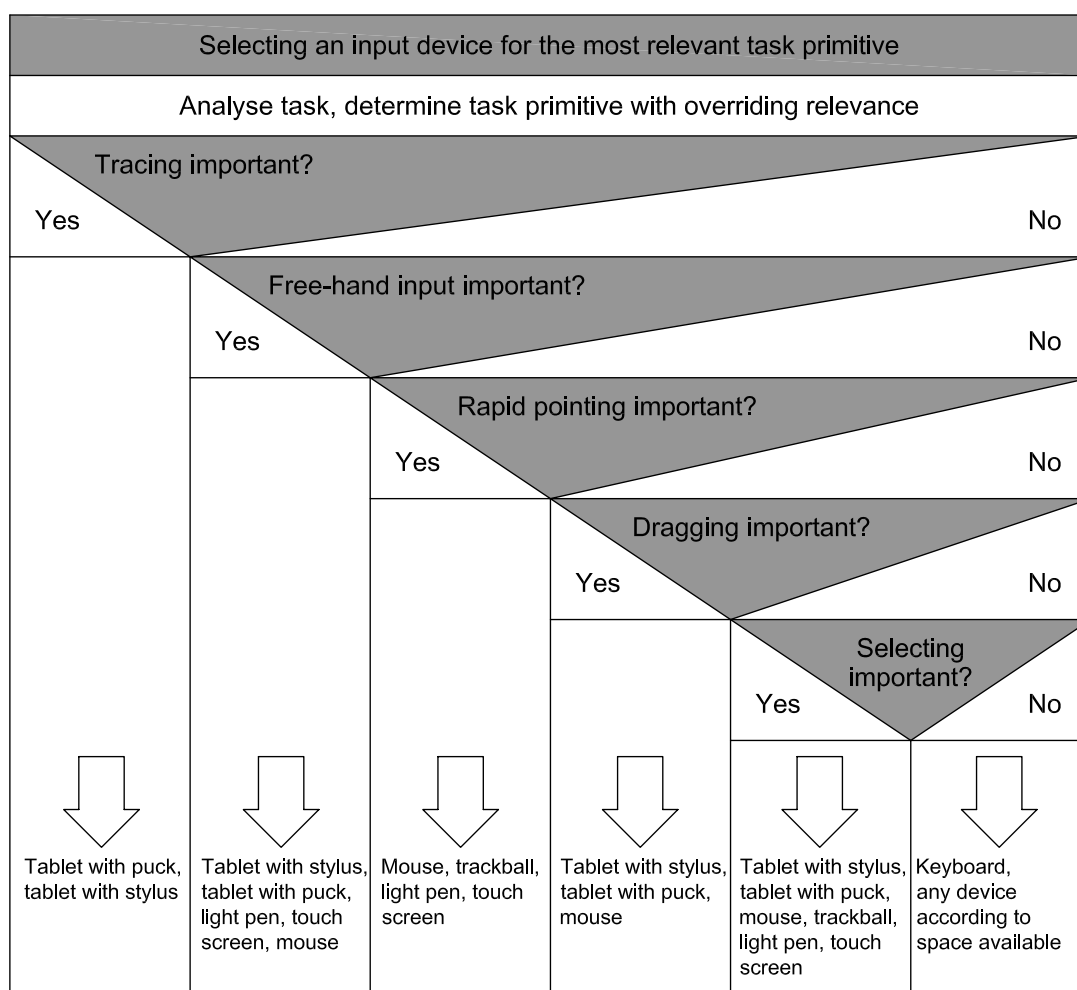


Figure 16 — Structogram for selecting input devices in consideration of most relevant task primitive

Table 2 — Selection based on dominant task primitive(s)

Suitability	Tracing	Free-hand input	Rapid pointing	Dragging	Selecting	Accurate pointing	Alphanumeric input
High	Tablet with puck Tablet with stylus	Tablet with stylus	Mouse Tablet with puck Tablet with stylus Light pen Touch screen	Mouse Tablet with puck Tablet with stylus	Mouse Tablet with puck Trackball Tablet with stylus Light pen	Tablet with puck Trackball Tablet with stylus	Keyboard
Medium		Mouse Tablet with puck Light pen Touch screen	Trackball Touchpad		Joystick Touchpad Touch screen	Mouse Joystick Touchpad Light pen	Tablet with puck Tablet with stylus Light pen Touch screen
Medium to low	Mouse Joystick Trackball Touchpad Light pen Touch screen	Joystick Trackball Touchpad	Joystick	Joystick Trackball Touchpad Light pen Touch screen	Keyboard	Touch screen	
Low	Keyboard	Keyboard	Keyboard	Keyboard		Keyboard	Mouse Joystick Trackball Touchpad

If the device under consideration needs to be supported by one or more devices, e.g. for accessibility reasons or for additional task primitives, another choice yields a more appropriate combination of devices for the support of the overall task.

This is also the case for the choice of the suitable keyboard shown in Figure 17.

6.5 Selecting a keyboard

For the task primitive “code entry”, i.e. the input of the entire code for a graphical entity (character, graphic primitive, etc.), the keyboard is the most likely candidate. While keyboards of technical equipment and machinery are often custom-made for specific tasks, keyboards used in other areas consist of more or less standardized elements, with the full-size keyboard being the most complex unit and a numeric pad with a stylus to hit very small keys the simplest.

The selection of the most suitable keyboard depends on its intended purpose of use, as shown in Figure 17. This graphic shows that a variety of designs can be appropriate under certain conditions, e.g. space restriction, portability, graphical user interface (GUI), whereas their usability without considering these conditions would suggest another selection.

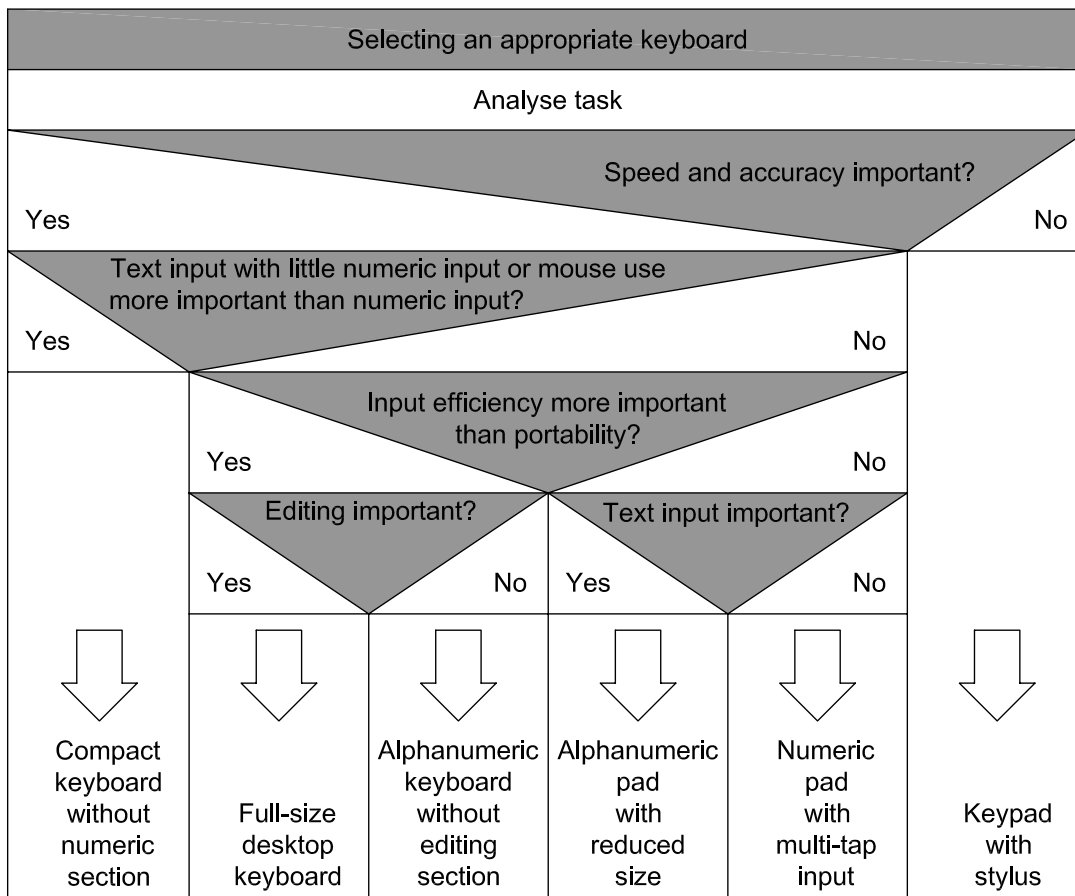


Figure 17 — Selecting keyboard for given task using structogram
(adapted from ISO 9241-410:2008, Figure B.1)

The following conclusions may be drawn from Figure 17.

- For general-purpose use of computers with GUI, the compact keyboard is the appropriate solution.
- The restrictions caused by portability lead to reduced input efficiency. If this aspect is still relevant, however, the restricted abilities of the physical device should be enhanced by software support. As known from the literature, a variety of (mostly language-dependent) methods exists with different effects. Some enhance effectiveness (correct input), while others increase efficiency (e.g. reduced effort for the same amount of input).
- An alphanumeric pad with keys reduced in size to fit the device can be an alternative to the numeric pad with multi-tap input as used by most mobile phones. Since such devices are being used to create billions of text messages [short message service (SMS)], checking the usability of the alternative is advisable.

7 Field assessment of input devices

7.1 Rationale

Testing a device may be necessary for a number of reasons, with missing information relevant to the actual context of use being the most important; therefore, user testing is always advisable. In general, products are designed assuming a certain context of use that may be different from the conditions in the actual environment. Thus, the information given in the product documentation may not be correct or complete for a given situation.

In addition, in many cases, product documentation may not be complete or suffice for a decision. Sometimes, the information can be existent but not suitable for selecting the appropriate device because its meaning for the task at hand is not clear. For example, the unit of measurement of the resolution of both a tablet and a mouse is given in dots per inch (dpi), a measure also used for printers and visual displays. Unfortunately, none of the measures is obvious. Is the quality of a printed image with 4 800 dpi fifty times better than that of an image on a screen with 96 dpi? Using a tablet, the absolute location in space is detected while for using a mouse, the number explains the number of counts the device makes while moving over a distance of one inch. Comparing a tablet and a mouse with the same “dpi” thus does not make much sense, because the user is interested in the speed and accuracy of the task completion rather than in technical numbers that sometimes confuse instead of informing.

These and many other reasons can justify a user test, which is why user testing is always advisable (see Annex D). But it should be kept in mind that ill-designed and poorly performed tests can be misleading.

All methods described in this part of ISO 9241 are simple tests with low requirements on test equipment. The design of the tests takes into account the fact that user organizations usually do not operate sophisticated test units, even if some might.

Annexes B to I of this part of ISO 9241 present the following applicable tests:

- Annex B: tracing test;
- Annex C: dragging test;
- Annex D: assessment of comfort;
- Annex E: one-direction tapping test;
- Annex F: multi-directional tapping test;
- Annex G: test for mobile text entry (hand-held keyboards);
- Annex H: tables for selecting devices in consideration of product description;
- Annex I: usability test for keyboards.

7.2 Methods

7.2.1 Subjects

7.2.1.1 Number of subjects

Selecting the appropriate test population is the most important task before running the test. The number of subjects is crucial for the importance of the outcome. For tests that are planned as a refined inspection method, five subjects can suffice.

For tests where statistics are to be calculated, the number of subjects should be around ten. This number can be found in many publications of the computer industry. Also, university researchers do not employ a considerably higher number of subjects for most experiments. The optimum number for tests is 20 or more if it is intended to achieve a high statistical power for the analyses with the least effort.

7.2.1.2 Qualification and skills of subjects

More important for the quality and reliability of the results are the skills of the subjects, if different types of devices or different designs of the same type of device are to be compared. For example, the typing performance of skilled touch typists can differ by a ratio of more than 1:2, while “hunt-and-peck” typists achieve about 20 % of the performance of highly skilled typists. Even larger differences may occur in the use

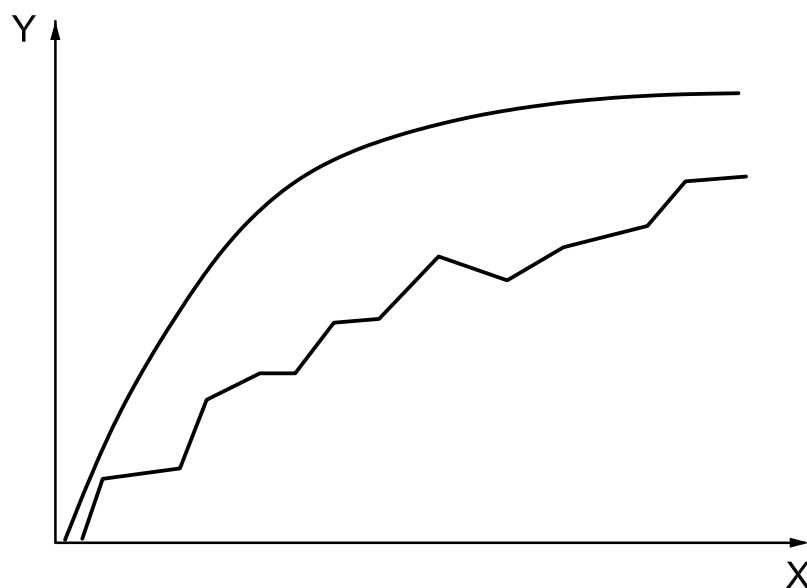
of pointing devices by normal users as opposed to graphic artists or persons using the keyboards of mobile phones for text entry.

Since the subject populations for user testing are relatively small, they cannot represent the actual user population in an organization. Thus, it is advisable to select a homogeneous group with certain abilities, i.e. a group of persons with similar characteristics. These abilities should be suitable for the purpose of the test. For example, if avoiding the interference of software with text input is the most important issue, touch typists with good skills are to be preferred. Whereas, employing the most skilled subjects for the selection of an appropriate pointing device to be used for administrative tasks may turn out to be counterproductive. In this case, subjects with good knowledge of the overall task and average skills in pointing can be more appropriate.

If the consideration of persons with special needs (e.g. elderly users, users with longer reaction times or lower levels of dexterity) is necessary, special attention should be given to the composition of the test population.

A serious problem concerning the skills and the qualifications of the subjects lies in a lack of suitable subjects. For example, by testing novel keyboards with skilled touch typists, the novel design is very likely to fail because the subjects have to unlearn and relearn their typing skills, an impossible mission. Even finding subjects with no keyboard experience may be a serious problem.

In many cases, using the so-called learning curve can help. This curve depicts the development of skills of persons or organizations through learning processes. See Figure 18.



Key

X trials/time

Y competence

Figure 18 — Progress of skills or competence through learning in theory (thin curve) and in real example

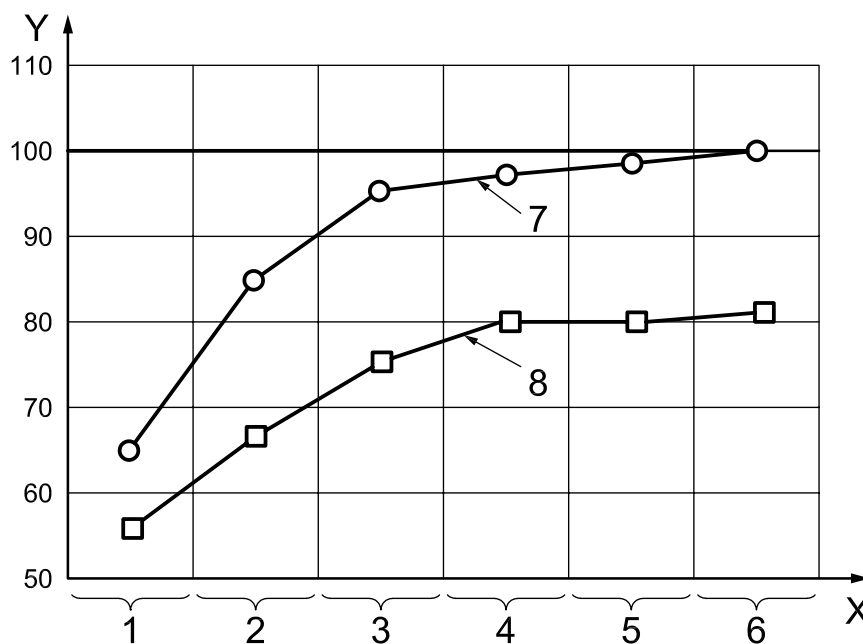
If two devices are to be compared, the likeliest situations are either that both devices are unknown to the subjects or that one of them is unknown. If both are unknown, they can be tested against a known device (e.g. a mouse). Figure 19 shows the outcome of a test where two new devices have been tested against a mouse. The curves reveal that unknown device 1 requires about five trials to achieve the same performance as with the mouse, whereas unknown device 2 shows no more progress.

For performing a test with device 1 in comparison to a mouse (known device), prior training of approximately the length of four sessions is required, with the length of each session depending on the type of device. If two

unknown devices are to be compared, the test can be stopped when it can be decided that the learning curves are unlikely to cross.

NOTE Most input devices are unlikely to reach the performance of skilled use of a mouse. In the given example, the tasks were administrative tasks such as pointing for text editing.

Devices designed or intended for use by unskilled persons may be tested without prior training. However, in this case, a comparison with a known device can be meaningless.



Key

1	training	5	session 4
2	session 1	6	session 5
3	session 2	7	device 1
4	session 3	8	device 2
Y	percentage of performance with mouse		

Figure 19 — Comparison of learning curves for two unknown devices with device used skilfully by subjects

7.2.1.3 Test environment

The test environment should be free of distraction from noise or lighting. Test subjects should be allowed to adapt to the test environment for about 15 min prior to the test. The test subjects should be kept at this level of adaptation throughout the test.

7.2.1.4 Test workstation

If a support surface is necessary, such as a desk, a workstation with similar properties to the intended or likely equipment should be used. It is advisable to use adjustable chairs and tables to avoid any influence of the specific subject population anthropometry.

7.2.1.5 Device assignment

If two or more devices are being compared, each subject should be tested using each device. The input devices should be labelled anonymously (for example, "A" and "B") and all identifying logos and labels should be covered. The order of presentation should be counterbalanced to eliminate any effects of test order.