A Taxonomy of Microinteractions: Defining Microgestures based on Ergonomic and Scenario-dependent Requirements

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Abstract. This paper explores how microinteractions such as hand gestures allow executing a secondary task, e.g. controlling mobile applications and devices, without interrupting the manual primary tasks, for instance driving a car. We asked sports- and physiotherapists for using props while interviewing these experts in order to iteratively design microgestures. The required gestures should be easily performable without interrupting the primary task, without needing high cognitive effort, and without taking the risk of being mixed up with natural movements. Resulting from the expert interviews we developed a taxonomy for classifying these gestures according to their use cases and assess their ergonomic and cognitive attributes, focusing on their primary task compatibility. We defined 21 hand gestures, which allow microinteractions within manual dual task scenarios. In expert interviews we evaluated their level of required motor or cognitive resources under the constraint of stable primary task performance. Our taxonomy poses a basis for designing microinteraction techniques.

Keywords: gestures, microinteractions, dual-task, multitask, interruption.

1 Introduction

Human-computer interactions are to a great extent defined by hardware design. That, again, depends on size limitations and interconnections of the hardware components. For instance, the size of current smart phones is mainly determined by the screen size necessary for watching multimedia content or browsing the internet.

Novel concepts of interaction design and HCI research tend to split the interface into tiny and specialized components, especially for separating the hardware that process the user input [5, 8, and 15]. For example, Loclair [8] uses a depth camera for tracking pinch gestures; Harrison [5] measures body transmitted acoustic signals that are generated by tapping a finger against other fingers or the forearm; and Saponas [15] is using EMG to recognize finger pressure and finger taps. These works focus on the input and sensing techniques for tracking hand gestures for microinteractions.

Microinteractions, which are defined by Ashbrook as short-time interruptions of primary tasks [1], have the huge benefit of allowing mobile application control in parallel to ongoing primary tasks and could significantly expand the set of tasks we could perform on-the-go. Chewar [2] defined secondary tasks as those which can take place concurrently with the primary task. However, there is a research gap in investigating microinteractions from the use case side and from the human point of view [17].

We understand a microinteraction as interactions which are task driven and goal oriented, and which may include system feedback. They can be evaluated with traditional usability metrics like effectiveness, efficiency and user satisfaction. In contrast, microgestures are actual physical movements, e.g. of fingers, which are recognised by the system, and where the system reacts upon. Microgestures are part of microinteractions. Within the related work of microinteractions, the main focus is on manual motor short-time interruptions or on manual synchronous tasks. We investigate microinteractions that can be performed synchronously. The cognitive resources then have to be used alternately or in parallel.

This paper explores which hand gestures are performable beside a manual task by requiring cognitive load that does not disturb the primary task, but also which hand gestures are performable in parallel a manual task. For exploring the manual primary task, we had a look on manual grasp research that is done in rehabilitation and medical science.

Feix [4] developed a grasp taxonomy that compared 14 grasp taxonomies based on 92 years of human hand's research. He identified 33 different human natural grasps and classified them into 3 main types: palm, pad, and side. We abstracted this taxonomy and related it to our research interest: microgestures performed alongside manual tasks (see Table 1). The left three columns of the table show the original main grasp types of Feix' taxonomy and describe one specific example for each type. The right column shows which free movement potentials we identified for the taxonomy's main grasp types. For investigating microinteractions that are meant to be executable alongside manual tasks, we have chosen 3 exemplary tasks: each one is using one grasp of one main group of Feix' taxonomy. Thus, we aim for ensuring research results that are scalable to a wide range of manual activities.

Primary tasks such as driving a car or holding objects do not need our complete cognitive effort nor are all fingers strictly involved into these processes. This allows for performing a second task at the same time. This task can be related to a different context like answering the phone while driving a car. But controlling mobile applications by microinteractions also offers the opportunity to add augmented function to the primary task without interrupting it. For instance, the input for many mobile applications in the automotive context, such as setting up the navigation system, controlling the music player, or opening and shutting the car windows, could be realized by microinteractions that are performable without releasing the steering wheel and therefore not interrupt the manual effort of the primary task.

Table 1. Microgesture options during ongoing manual tasks: Analysis of Feix' grasp types: Palm, Pad, and Side, into which all human grasps can be categorized. Fingers are counted starting from the thumb.

Grasp type (Feix [4])	**Description** (Feix [4])	**Involved hand-parts** (Feix [4])	**Potentially still movable hand-parts**
PALM (e.g. Steering a car)	 Medium wrap	Low power grasp performed by 2-directional force between palm (finger 2-5) and abducted thumb	Particular fingers and thumb
PAD (e.g. Inserting a cash card into an ATM)	 Precision grasp	2-directional force between abducted thumb and index finger	Finger 3-5: middle, ring, and little finger
SIDE (e.g. Drawing with a stylus on a graphic tablet)	 Dynamic tripod	2-directional force between: a) added thumb and middle finger while index finger stabilizes or b) thumb and index finger while middle finger stabilization	Ring, little finger Stabilizer: index finger or middle finger

For the palm grasp for example, we have chosen driving a car as primary task that allows microgesture commands such as tipping or dragging at the steering wheel (see Fig.1).

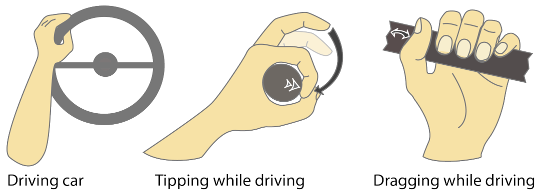


Fig. 1. Performable microgestures while steering a car with a palm grasp: Tipping fingers on the wheel or dragging it with the thumb.

In contrast to the chance of enriching the primary task conceptually by allowing a secondary simultaneously; there is a risk that the performance of the primary as well as of the secondary task decreases because of cognitive resource restrictions. [3, 20]

2 Related Work

We relate our work to research that is investigating microinteractions performed by hand gestures. We focus on the effect of multitasking on motor and cognitive efforts, on gesture-based interaction techniques as well as on wearable gesture tracking systems that do not limit the hand skills like data gloves do by reducing the touch sensitivity of the hand.

Within the human-factors related research, multitasking is investigated focusing on task interruptions and cognitive effort issues of both: the primary and the secondary task. While Wexelblat [19] and Quek [13] claim that gestures are not natural for computer interactions, because they only represent a small part of human communication, Karam [7] suggests that this “small part” is potentially well matched to secondary interactions. McCrickard [9] investigated the effects of distraction and recovery caused to a primary task (editing a text document) by a secondary task interruption, which was a notification for receiving a instant message. For the specific case of dual-task-microinteractions, there is a gap of research about how to design dual-task scenarios and how to select microgestures. For keeping the performance stable, there are two strategies: alternating two tasks or performing them in parallel by using cognitive resources in parallel as well.

Wickens’ Multiple Resource Theory (MRT) Model describes that cognitive resources can be used in parallel if they apply different input modalities, different task stages, or different reasoning, such as linguistics, symbols, or subconsciousness [20]. Based on Wickens’ Multiple Resources Theory [20], Oulasvirta [12] developed the Recource Competition Framework (RCF). He is investigating cognitive resources when users are on the move. Oulasvirta explains that the resources are partly reserved for passively monitoring and reacting to contexts and events, and partly for actively constructing them. This model suggests that the resources for competitive task interactions alternate through breakdown the primary fluent interaction for up to four seconds.

Another research field that concerns about microinteractions and especially about their trackability and classification is computer science. Computer vision based gesture tracking for identifying pinch gestures has been investigated by Loclair [8]. Vardy [18] tracks finger flexion with a camera integrated in a wrist band. Howard [6] uses optical detectors (that are also integrated in a wrist band) for measuring LED light that is reflected by the fingers. Harrison [5], Saponas [15], and Rekimoto [14] measure hand gestures by body transmitted signals, such as acoustic signals, EMG, and electrodes that display forearm movements by capacitive sensing.

So far, several multitasking scenarios and interaction techniques have been explored and tracking technologies for microinteractions have been developed and evaluated. But there is still a research gap in classifying microinteractions regarding their ergonomic dual-task potential. We investigate which microgestures might be best suited when applying secondary tasks in addition to certain exemplary primary tasks. Therefore we aim for developing a taxonomy based on fundamental ergonomic and anatomic hand research [4]. Our taxonomy can serve as basis for developing novel microinteraction-based interfaces.

3 Method

The goal of our study was generating a taxonomy for microinteractions by listing and evaluating all microgestures that are performable alongside the main grasp types. The taxonomy aims to develop a general hand gesture set as well as to display ergonomic issues of the hand gesture performance, the necessary cognitive effort to perform the gestures, and the risk that the gesture is performed unintentionally as a natural movement and therefore would be misinterpreted as an input command.

A common method for defining gestures in the HCI field is to involve users into the design process [21]. To create a gesture set that already contains gestures of good feasibility and to generate valid data about how the majority of the users will be able to perform these gestures while continuing a manual task, we decided to involve experts, who know about the motor abilities and limitations of the majority of the users. Therefore we interviewed 1 sports- and 3 physiotherapists separately and asked them for evaluating a gesture set using props (see Fig. 2) regarding ergonomic and scenario-related aspects as well as for finding more gestures that might suite to the use case.

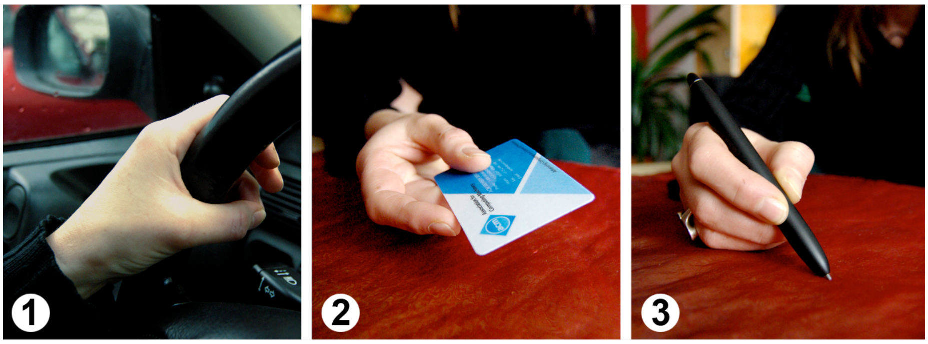


Fig. 2. The participants are testing the feasibility of hand gestures while (1) holding a steering wheel (2) targeting a cash card, and (3) drawing with a pen.

We interviewed the experts separately in two sessions (see Fig. 3). We started the first session with a prepared set of 11 hand gestures, which were graphically presented and that should be evaluated by the experts. This initial gesture set consisted of 7 palm-gestures, 2 pad-gestures, and 2 side-gestures, which already were used within microinteraction research projects [1, 5, 6, 8, 14, 15, 18]. For each gesture we asked the experts for evaluating its performability through answering questions, which were structured, explained, and asked as described here:

Feasibility. How easy is a hand gesture performable regarding ergonomic aspects when it is done eyes-free?

Limitations. Which ergonomic aspects limit the hand gesture performance?

Cognitive effort. Human-computer interactions require (depending their design and the experience level of the user) more or less attention (cognitive load) for some, but not all of their (7 [11]) interaction stages that are for instance goal definition, finding the right interaction technique that would support reaching that goal, and performing the interaction technique. When we are using a mouse, this happens automatically because we practiced it so many times. But because users might not be used to perform the gestures we collected. For instance the vulcan salute, known from the Star Trek series, is not easy performable by many users. Therefore we ask. Does the pure gesture performance require low, medium, or high attention?

Mixing-up risk. Is there the risk that a hand gesture could be mixed-up with natural movements? This happens easily when there is a formal similarity between natural movements and natural gestures and a gesture that is defined as an input command. Then an unintentional movement could be misinterpreted from the computer as an input command and result frustration on user's side.

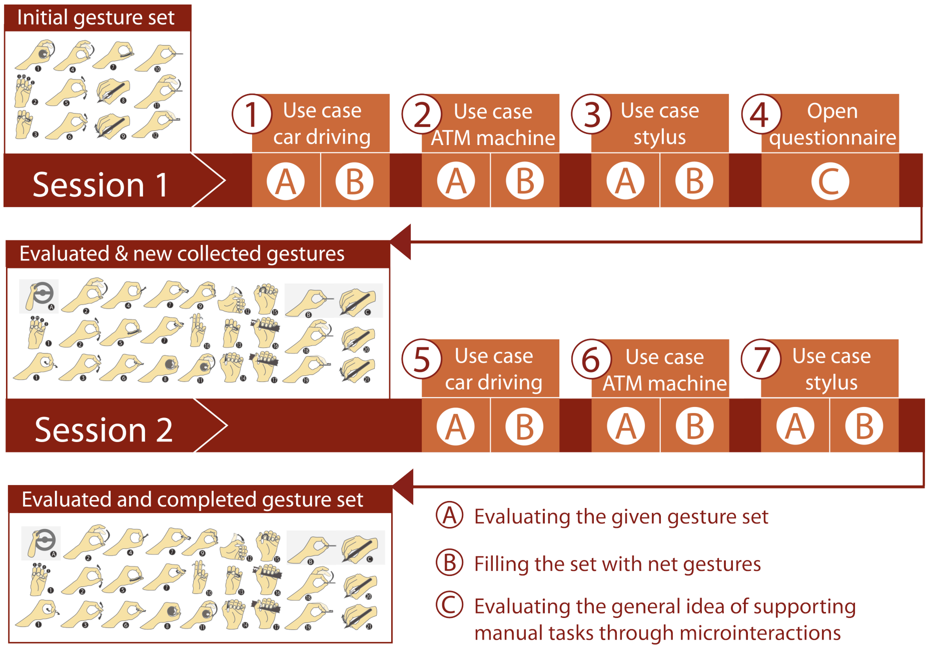


Fig. 3. Experiment walk through: We interviewed the experts separately in 2 sessions. The first started with a pre-defined gesture set, which the experts evaluated using and completed using props. An open questionnaire completed the first session. Within the second session, the new collected gestures were evaluated by the experts by walking through the use cases with help of props again. The result was a completed and evaluated gesture set that shows feasible hand gestures that can be performed while continuing the main tasks that are given by the use case.

For evaluating the different performance parameters in phase 1-3 and 5-7, we used different scale ranges: For the feasibility we asked to distinguish between easy (+) and hard (-). The cognitive effort were valued “low”, if the gesture execution is easy performable without influencing the main task performance. The value is “medium”, if the gesture execution requires some of the cognitive resources from the main task. The value is “high” if executing the gesture needs to be checked by visual attention or if the main task might be interrupted. The parameters issue of limitation, such as finger separation, as well as the mixing-up risk were asked to explain by the experts for understanding the reason of limitation and understand which misinterpretation could be suggested. Within the evaluation section, we took notes of the verbal comments. Within the creation section, we took photos and drew sketches of the gestures the experts were performing.

After all evaluations of given gestures in one session, we asked the experts within the creation section to describe and perform further gestures that suite to the specific context. We took pictured of these new identified gestures and added them as a graphical presentation to the gesture set for the next interview session.

The first sessions finished with an open interview about the expert’s general opinion about the idea to support a manual main task through microinteractions and took notes of the verbal comments.

4 Results

The outcome of our iterative interviews was a list of 21 expert evaluated micro-gestures: 17 palm-, 2 pad-, and 2 side-gestures, as shown in figure 4 and described in greater detail in table 2.

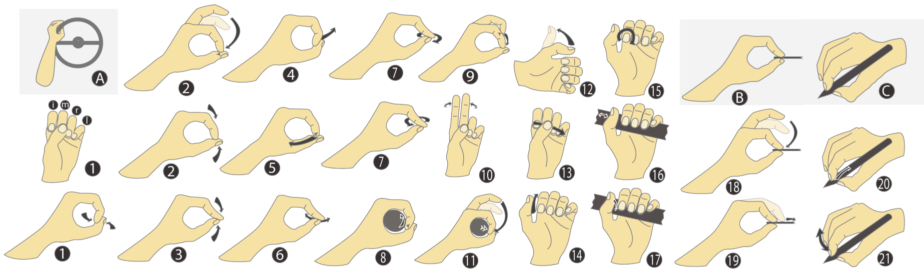


Fig. 4. The expert-defined and evaluated hand gesture set. The experts found 17 gesture types for the driving scenario (A). The card targeting scenario (B) and the stylus scenario (C) just contain 2 gesture types each. Most gesture types have several sub-types by performing them with different fingers (index, middle, ring, and little finger). Moreover the same gesture results in a different sub-type (e.g. touch, tab, or press), if it is performed with different acceleration or duration (see Table 2).

The very similar evaluation outcome of different interviews regarding the valuation of the hand gesture’s required motor and cognitive effort, allowed for comparing and concluding the results into one single table (see Table 2). The opinions we collected during the interviews are subjective expert arguments. In case there were different opinions about the feasibility or cognitive efforts of a hand gesture, we chose the more negative ones in order to exclude the less feasible gestures from further examination, and to make sure that the taxonomy will work for a large number of users. In the following, the results in Table 2 will be described in detail.

Arguments for valuing ergonomic issues built the sub-classifications: feasibility, finger separation problems, and arguments that described why some gestures were hard or impossible to perform (limitations). We identified arguments which describe how well the primary and the secondary task are fitting together into a simultaneous task performed situation. Within this category we split the participants' comments into the sub-groups: cognitive effort and mixing-up-risk. The cognitive-effort-comments describe if the in parallel performance of certain gestures requires high or low cognitive effort. The mixing-up-risk-comments value the risk that a gesture is performed randomly as natural gesture or movement.

4.1 Feasibility and limitations

As a matter of cause, we asked the experts for showing us feasible hand gestures. But in some cases, certain gestures have circumstance-dependant feasibility. For instance the feasibility of touching, pressing, and tapping the fingers on the thumb while holding a steering wheel is dependant on the finger length and the wheel diameter (see Fig. 5). Usually our fingers are long enough to surround a steering wheel, but persons with small hands may have problems to reach the thumb with the little finger.

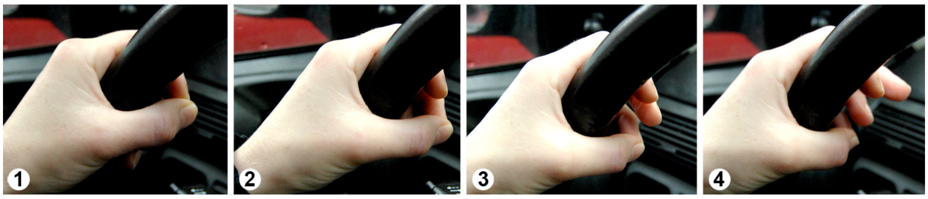


Fig. 5. shows the feasibility of the third gesture of table 1: The thumb can be tapped easily with the middle (2) and the ring finger (3) while holding a steering wheel. But depending on the wheel diameter tapping the thumb with the index (1) or the little finger (4) can be difficult, especially for people with small hands.

Beside the object diameter, the most feasibility limitations are reasoned by lacks of flexibility of certain fingers when "neighbor" fingers should not follow the movement: the finger separation problem. There was a significant difference in accuracy between the index, middle, ring, and little finger, while performing some hand gestures, such as tapping a single finger on the thumb (Table 1, gesture 3),. All experts were sure that the majority of the users will be able to perform an index-finger tab without any problems. Also, to the move the little finger separately from the others was not a problem at all. The flexibility of the middle finger was a bit lower than of the index finger, but it was still movable separately. However, the ring finger is always difficult to stretch separately. The rate of inflexibility varies individually; but the ring finger is valued as the worse separately movable. This means that when our hand is performing a palm grasp and we aim to just stretch the index finger; we will be able to do this. In case we want to just stretch the ring finger out from a palm grasp, we will move also the little and the middle finger (see Fig. 6). The experts reasoned this motor limitation of the ring finger by the human hand anatomy (see Fig. 7).

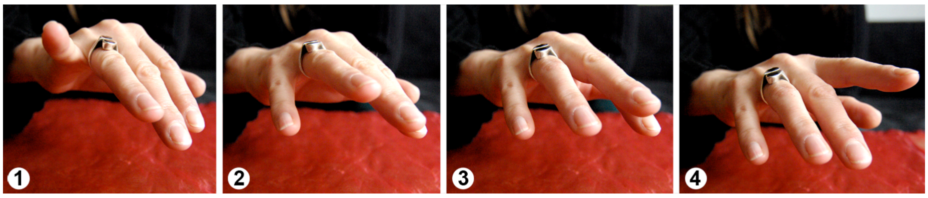


Fig. 6. shows the difficulty of stretching the ring (2) and middle (3) finger separately. Stretching the little (1) or the index (4) finger is much easier because of human hand's anatomic architecture which is shown in greater detail in Fig. 6.

The sports scientist expert explained this motor limitation and reasoned it anatomically by the connection between our muscles, sinews, and the fingers (see Fig. 7). Humans have more than 40 muscles to move the arm, hand, and fingers. If we want to stretch the ring finger out from a palm grasp; two muscles (M. flexor digitorum profundus & M. flexor digitorum superficialis) are bending synergetically the index, middle, and little finger to bring them into the palm position. In addition another muscle is responsible for stretching the ring finger (M. extensor digitorum). But because this muscle is also responsible for stretching the other fingers and because the ring finger has a physical connection to the middle finger (Connexus intertendineus), the middle finger will always move a bit in the same direction as the ring finger does. The little and the index finger are more independently movable because they have their own muscles for stretching.

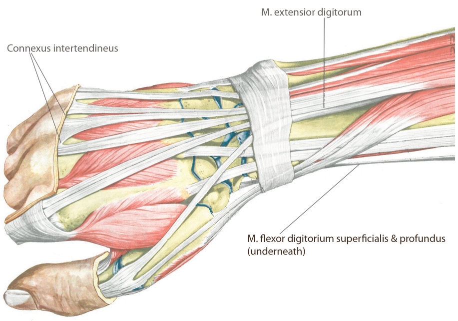


Fig. 7. shows the anatomic connection between the fingers that is responsible for the separation problem of the ring finger. Fig. 7 is a simplification of a figure in Spalteholz' Anatomy of Human [16].

4.2 Mixing-up risk

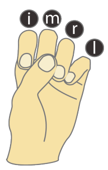
If commands released by body movements there is a risk that subconsciously executed natural movements are misinterpreted as commands. For example, tabbing the steering wheel while driving a car (tab. 1, gesture 16) is a common behavior while waiting at crossroads and / or listening to music. Reaming thumb and index finger would be expectable while cooking or eating for putting salt onto the food; but while driving the mixing-up risk of a ream-gesture with a randomly executed natural movement is expected to be low.

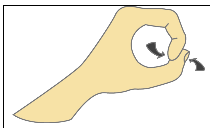
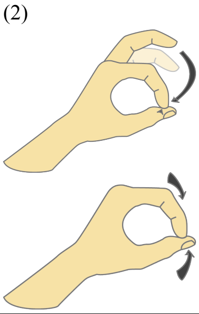
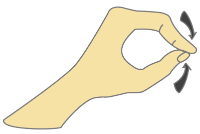
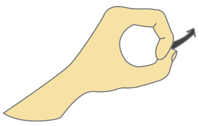
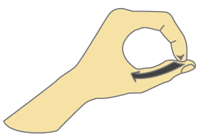
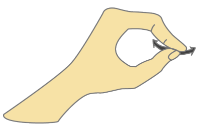
4.3 General idea

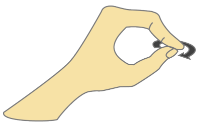
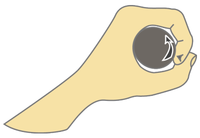
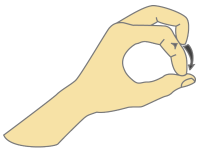
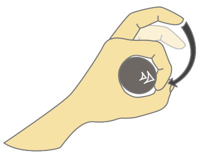
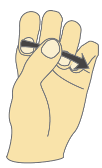
Beside the hand gesture evaluation, we also got verbal comments of the experts on the general idea of allowing a secondary task beside a continuous primary one. The opinion about the benefit of performing two tasks in parallel was different from one scenario to another. All experts think there is a huge benefit in control a secondary task besides driving a car. An often used example within these arguments was that drivers are anyway performing secondary tasks while steering a car such as setting up the navigation system, controlling automotive functions, or using mobile devices like cell phones. The concept of controlling these devices or applications without releasing the steering wheel was valued positively for security arguments. The scenario of performing hand gestures while inserting a cash card into an ATM was not liked at all. None of the experts thought in parallel tasks could have a benefit for this use case. The last scenario about pen computing (e.g. drawing with a pen- or stylus-like input device on a graphic tablet) was modified during the interviews. Three of the experts thought that the possibility to change the stroke width or the color while drawing would have a bad effect on the precisions of the primary task. But all of them said that having these options during short time interruptions could have a benefit for the primary task. The flow of drawing would not be interrupted and therefore the task could be designed more comfortable than if a color selection would have to be done by keyboard or button-selection.

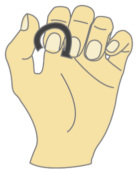
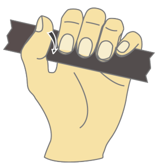
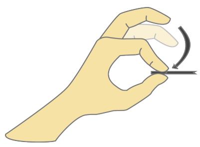
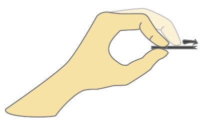
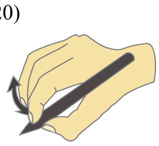
In general the experts think palm grasp tasks suite best for dual-task scenarios because these tasks are often low precision task and therefore it takes lower cognitive load than pad or side grasp tasks.

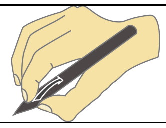
Table 2. Microinteraction taxonomy. I =Index Finger, M=Middle Finger, R=Ring Finger, L=Little Finger, Th=Thumb, +=easy, –= difficult.

<table>
<tr><th>Gesture</th><th>Action</th><th>Ergonomic</th><th>Scenario compatibility</th></tr>
<tr><td colspan="4">Palm-grasp gestures</td></tr>
<tr><td rowspan="2">(1)
</td><td>(a) Tab</td><td rowspan="2">Feasibility
Index (I):easy+
Middle (M): +
Ring (R): +
Little (L): diff. -
Limitation
By relation of finger length and hold object diameter, i.e.</td><td rowspan="2">Cognitive effort
Low:
Th (thumb), I, M, L
High: R, M
Mixing-up risk
Risk to be a randomly performed natural move:</td></tr>
<tr><td>(b) Touch</td></tr>
</table>

	(a) **Tab**	steering wheel	high
	(b) **Touch**		
	(c) **Press**		**Cognitive effort** Higher than Touch-gesture, pressure rate is hard to control **Mixing-up risk** High
(2) 	(a) **Tab**	**Feasibility** I: +, M: +, R: +, L: - **Separation** - : M+R **Limitation** By holding object diameter	**Cognitive effort** Higher than (1); Hard to distinguish from (3) **Mixing-up risk** High
	(b) **Touch**		
	(c) **Press**		
(3) 	(a) **Tab**	**Feasibility** M, R: + I, L: - **Separation** -: M+R **Limitation** Object diameter	**Cognitive effort** Higher than (1); Hard to distinguish from (2) **Mixing-up risk** High
	(b) **Touch**		
	(c) **Pinch**		
(4) 	**Flip**	**Feasibility** I: +, M: +, R: +, L: - **Separation** No problem **Limitation** Object diameter	**Cognitive effort** Low **Mixing-up risk** Low
(5) 	**Drag&Drop index on thumb**	**Feasibility** Just partly possible because of object diameter	**Cognitive effort** Medium **Mixing-up risk** Medium
(6) 	**Ream**	**Feasibility** I: +, M: +, R: +, L: - **Limitation** hold object diameter by L	**Cognitive effort** Low **Limitation** Object diameter **Mixing-up risk** Low

(7) 	**Circle sidewise**	**Feasibility** I: +, M: +, R: +, L: - **Separation** No problem **Limitation** Object diameter	**Cognitive effort** Individually different (+, -) **Mixing-up risk** Low
(8) 	**Drag fingers around the wheel**	**Feasibility** -	**Cognitive effort** Medium **Mixing-up risk** Medium
(9) 	**Drag&Drop middle on index**	**Feasibility** To complicated	**Cognitive effort** High
(10) 	**Snip**	**Feasibility** +	**Cognitive effort** Low **Mixing-up risk** Low
(11) 	**Tap the wheel**	**Feasibility** I-L: +, Th: -	**Cognitive effort** Low **Mixing-up risk** High
(12) 	**Thumb up**	**Feasibility** +	**Cognitive effort** Low **Mixing-up risk** Low
(13) 	**Drag&Drop thumb on finger nails**	**Feasibility** Over I, M, R: + L: - **Limitation** Object diameter	**Cognitive effort** Low **Mixing-up risk** Low
(14)	**Drag&Drop thumb on index-side**	**Feasibility** Just partly possible because of object diameter	**Cognitive effort** High **Mixing-up risk** Medium

		**Limitation** Object diameter	
(15) 	**Circle clockwise & contra-clockwise** (CW & CCW)	**Feasibility** I, M: +, R, I: - **Limitation** Object diameter	**Cognitive effort** Individually different (+, -), but high for CW- / CCW-distinguishing **Mixing-up risk** Low
(16) 	**Drag thumb along object**	**Feasibility** +	**Cognitive effort** Low **Mixing-up risk** Low
(17) 	**Drag thumb around object**	**Feasibility** -	**Cognitive effort** Medium **Mixing-up risk** Low
Pad-grasp gestures			
(18) 	**Tab**	**Feasibility** I, R:- M, I, M&I: +	**Cognitive effort** High
(19) 	**Drag middle finger above object**	**Feasibility** +	**Cognitive effort** High
Side-grasp gestures			
(20) 	**Tab I or M on object**	**Feasibility** I. While drawing: - II. While holding: +	**Cognitive effort** I. High II. Low **Mixing-up risk** I. High II. Low
(21)	**Drag Index or Middle finger on stylus up / down**	**Feasibility** While drawing: -	**Cognitive effort** I: Low, M: High **Mixing-up risk**

		While holding: +	Low

5 Discussion

The microinteraction taxonomy shows that the design of the hand gestures, as well as their evaluation concerning usability related issues (e.g., ergonomic issues and scenario compatibility), is extremely dependent on the use context that defines the primary task and rules the choice of the grasp type that is used to solve this task. The static gesture design as well as its feasibility (see table 1, column 1 & 3), is mainly influenced by grasp-related options, their hand anatomic limitations, but also ergonomic issues that are defined by objects and manual work of the primary task. Moreover the primary task determines the cognitive resources that are available to perform secondary task commands realized by microgestures.

5.1 Palm-grasp gestures

A low power palm grasp gesture allows for a great number of simultaneously performed microgestures without releasing the grasp. Palm related primary tasks that have a long duration use little cognitive resources by becoming an automatically performed process, and leave a large part of the hand resources quite uninvolved. Thus, they are well suited to be augmented by a large variety of microinteractions. Dependent on the character of the primary task, some microinteractions have a high risk of being performed unintentionally during the primary task. Tapping at the steering wheel could just be done by listening to music and playing finger drums on the wheel. To differentiate natural movements from input commands, three opportunities are possible for generating a gesture set:

1. Using a push-to-gesture event for telling the system that the parallel or subsequent movement is an intentionally performed command.
2. Designing commands as a combination of two gestures for reducing the chance of performing this couple unintentionally.
3. Defining design styles, e.g. rhythmic pattern, based on movements which are usually not done naturally in the primary-task-related context.

5.2 Pad-grasp gestures

Pad-grasp primary tasks such as inserting a cash card into an ATM machine have shorter durations, use the 2 directional finger-thumb-force permanently, and require a high level of precision and short-term concentration. This was shown by our expert through demonstrating the failed attempt to perform both tasks in parallel. An addition and augmentation of the primary task would require interrupting or slowing down the primary task for a short time while performing a microinteraction as a secondary task. According to the expert opinion, the interruption of the primary task is obligatory, because performing it quickly and accurately does not allow microinteractions in parallel. Any finger movements would disturb targeting the cash card into an ATM by dismissing the target or extend to targeting time. Targeting and alongside performed microgestures are not possible at the same time without risking high error rate at one or even both tasks. Moreover, the available hand resources for performing microgestures while interrupting the pad-grasp but still holding the tool are very limited.

5.3 Side-grasp gestures

Performing microgestures alongside a side-grasp drawing is hardly possible. Drawing is a highly precise manual task, is built from accurate hand movements, and does not allow for moving fingers at the same time without having a negative effect on the quality of drawing. However, brief interruptions (stop drawing but continuing to hold the stylus) would allow for microinteractions. There are just a few possible microgestures while holding a stylus. But these ones are quite easy to perform and require low recognition effort.

5.4 Dual-task suitability

In summary, several parameters have an effect on how well two tasks suite within a dual-task scenario, such as duration of both tasks and cognitive resource sharing (alternate versus in parallel effort). The suitability of two tasks depends on the level of required precision and needed cognitive load as well as on the synchrony of these requirements.

Comparing the evaluated scenarios, we argue that primary tasks, which have a long duration, are performed automatically, and require low cognitive, visual, we argue that primary tasks that are suitable for simultaneous microinteractions, should have a long duration, be performed automatically, and require low motor as well as cognitive effort. Of the conditions we evaluated, the palm grasp is the most promising for leaving enough motor resources for simultaneous hand gestures.

6 Conclusion and Design Guideline

Gestural interfaces miss affordances and constraints which are readily provided by other interfaces, such as graphical and tangible [10]. In particular, it is difficult to let users know what they are able to do, what they are currently doing or what they just have done. Because of this, gestural interfaces and in particular microgestures are not to be understood as a replacement for other kinds of interfaces, but rather as enabling novel ways of interaction. There are still many open questions to be answered, especially regarding interaction opportunity and feedback representation.

Our taxonomy is mainly investigating ergonomic interaction opportunities of microinteractions and can be used as a basis for designing microinteraction techniques for manual dual-task scenarios: First, the scenario has to be analyzed for defining the limits and requirements for microgestures. Then, and by having a look at the formal structure of the chosen gestures, a gesture set can be defined. Lastly, a decision about the sensory and tracking requirements of the hardware can be made.

6.1 Dual-tasking design

For a formal scenario design, we propose two synergetic strategies to guide the scenario design: the handling of cognitive resources as well as of motor ones.

The selection of the primary and the secondary task is reasoned by the usage of different cognitive resources. Our primary and secondary tasks use equal modalities by requiring tactile feedback and kinesthetic self-awareness. An automatically performed primary task requires low cognitive effort [20]. This allows for using cognitive resources for simultaneously performing secondary tasks such as microinteractions. These circumstances allow the handling of two cognitive resource requirements in parallel (Table 2, column 4). The example steering a car represents an automatically performed and adaptively aware task with low cognitive load. Controlling the navigation system by hand gestures could be a secondary one using available cognitive resources for processing.

The primary task defines the usage of motor resources as well as free potentials and available hand motor skills that can be used for simultaneous tasks. The grasp type that is performing the primary task (palm, pad, side) defines the motor resources which are used in the primary task (see Table 1, column 3). Our taxonomy identifies microinteractions executable in parallel based on free motor resources (Table 2, column 1-3) and allows to create a hand gesture set for commanding the secondary task.

6.2 Interface design

The chosen hand gesture set defines requirements for the interface design and the gesture tracking technique. For example tap-interactions should be tracked by a technology that provides a sequence of movement data like accelerometer. Gestures that base on a finger pressure are defined by punctual force and could be measured by sensors that are measuring muscle activities such as EMG. The different tracking technologies shall be discussed for their data quality, and their interaction usability under different conditions given by both the microgesture design and the primary tasks.

There are some primary task-driven requirements for the sensor selections beside selecting the best suited sensors to measure formal gesture parameters. Covering the finger tips with interface components such as touch sensors would limit the tactile feedback (sense of touch) of the finger and the ability to conduct highly precise tasks. Moreover the size and placement of the hardware could affect both the primary task and the ability to perform the input gestures. The interface design should not be annoying to wear and be as small and unobtrusive as possible.

7 Further Research

The developed taxonomy serves as an analytic basis for systematic microinteraction design. In a next step, we intend to ask users to perform these microinteractions while performing a primary task and ask them to rate the feasibility of the gesture as well as scenario-related usability and cognitive aspects.

So far, we increased the hand gestures regarding to their ergonomic structure and did not analyze their semiotic potentials. But within our interviews, we also got some comments about what the gestures could communicate. For instance, the thumb-up-gesture (see Table 2, gesture 13) was commented to suit for okay-commands such as answering the phone or selecting a menu item. The taxonomy has some meaningful gestures, such as forming the index finger and the thumb to an "O" for communicating an "Okay". A snip gesture (see Table 2, gesture 12) could mean to cut something, and to put the thumb up (see Table 2, gesture 13) is commonly understood as "Okay", too. When the gestures are linked to specific meanings and commands, it will be necessary to not just pay attention to the feasibility of a gesture but also to its potentials of association, guessability, and meaning.

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