STABILO®

ErgoPen® Neo

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User Manual

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Essential ErgoPen Neo Information

USB-Charging socket

The battery charge level is indicated in the app

LED Indication Light

Slowly blinking orange: Battery is charging

Slowly blinking green: Battery is fully charged

Two blue flashes: Startup process

Slowly blinking blue: Ready for Bluetooth connection

Solid blue: Bluetooth connection established

Slowly blinking violet: Battery is almost empty

On-Off Switch

Double blinks orange: Hardware defect

During charging: Pen has overheated

LED dark: Pen is switched off

Ergonomic gripping zone

Ballpoint tip

2 Icons used in the ErgoPen Neo App

Icon	Meaning	Icon	Meaning
	Battery level of the ErgoPen Neo-Battery		Information about exercises
	No ErgoPen Neo is connected with the ErgoPen Neo App		Information about pen posture, grip pressure
	Bluetooth®-communication between ErgoPen Neo and app is initiated		Information about finger position along the gripping zone
	The ErgoPen Neo is connected with the App		Information about the writing direction on the paper
	Connect with the pen		Information about paper position
	Share and print material		Information about body posture
	Show example		Information about handedness
	Show detailed report		Add entry
	News center		Cancel process
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	Adjust pen settings		Mean value of the normal range in the reference data
	App settings		View and create reports
	Enter practice data		Live feedback
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3 Introduction to the STABILO ErgoPen Neo Pen and App

3.1 Unique features of the ErgoPen Neo App

- Digital measurement of grapho- and writing motor skills: The client writes with the STABILO ErgoPen Neo on regular paper.
- At the same time, the app evaluates writing and graphomotor parameters.
- Clear presentation of the writing and graphomotor abnormalities and comparison with more than 1,300 reference data (database steadily growing) in diagrams.
- Training of Grip and Writing Pressure with live feedback training.
- Treatment progress and success are measurable and verifiable.
- Automated reporting with plots of the development history.

3.2 Purpose of pen and App

The STABILO ErgoPen Neo enables evidence-based promotion of writing motor skills because it records individual grapho and writing motor movements of the client during writing. The associated app uses this information to create a client's personal writing profile and derives exercise recommendations from it. The goal is a quick, objective analysis to facilitate the differentiated, focused training for the development of automated handwriting.

Test	Analysis
The client writes as usual with the ErgoPen Neo on paper. Nine standardized test tasks form the basis of the measurement of writing motor skills.	The ErgoPen Neo analyzes the parameters for the qualitative assessment of the writing motion: Duration, writing and grip pressure, frequency, degree of automation, and pen angle.

Result	Report	Live Feedback
The ErgoPen Neo App displays the measured paramters clearly. 1300 (and growing) stored reference data sets allow an age-corrected comparison, so abnormalities stand out.	An automatically generated report clearly shows the progress in each parameter of each test. The therapeutic success can objectively be proven.	Live-Feedback allows for active training in your occupational therapy and enables you to do fatigue testing as well.

Writing begins with something akin to painting: In the beginning, conscious hand-eye coordination is required to get the desired trace on the paper. With increasing experience, these movements are automated and require less attention, but still occur faster. An automated handwriting is essential for school success: If the client does not develop automated writing, this not only leads to a significantly slower handwriting, but also puts a considerable strain on attention and working memory. If a client has to concentrate mainly on the writing process, it becomes difficult to follow the lessons at the same time. But not taking notes is also not a solution: Notes significantly improve what you have learned, especially if they are created by handwriting. Studies have shown that creative tasks can achieve up to 38% more

relevant solutions when done by handwriting[1] and with handwritten lecture notes, knowledge is retained significantly better than when typing.

In order for handwriting to be used effectively, the client must be carefully introduced to automated writing. If too much is asked too early, avoidance strategies occur, the writing tilts and becomes illegible. At the same time, the writing hand will experience pain, handwriting is perceived negatively and avoided if possible. The result is a vicious circle of declining academic performance and even less use of handwriting; the disadvantaged clients cannot realize their potential, which has negative, lifelong consequences for them. With the ErgoPen Neo there is now an objective measuring device that shows the state of writing and graphomotor skills and recommends suitable exercises.

3.3 Installation of the ErgoPen Neo App

The ErgoPen Neo App can be downloaded from the Google Play Store rsp. the Apple AppStore. This symbol should appear on your screen after installation. When the app has launched, please allow it to access location information on Android in order to enable Bluetooth functionality. Check in the tablet's setting menus whether Bluetooth is endabled. Meanwhile, it is advisable to charge your ErgoPen Neo on a USB port of a computer or using the supplied charger and USB cable. The charging time is about 3 hours. As long as the battery is not fully charged, the LED on the lower side slowly blinks orange. This light turns green when charging is complete. Next, switch on the pen and pair it with the app as described in section 3.4 below.

Softwareupdates - Co-operation between Pen and App

In order for the ErgoPen Neo and the App to work together in an optimum way, both should always be kept up to date. Please check regularly for new updates available in the Google Play Store rsp. the Apple AppStore. The pen firmware update process is explained in Section 4.7 on page 10.

3.4 Pairing with the ErgoPen Neo

On first use you need to pair your ErgoPen Neo with the app. Please turn on the ErgoPen Neo by depressing the round button on top of the pen body. There should be a noticeable click and the button should be kept pushed until the LED lights up. The LED in the ErgoPen Neo binks twice blue which indicates the loading of the internal programming. Next, the ErgoPen Neo slowly flashes blue, indicating that it is ready to connect. If the LED does not respond even after more than 2 seconds or shows a different color than blue, please proceed as described in section 10.1 on page 35.

After launching the app, it looks for a device that it can connect to via Bluetooth Low Energy (BLE). If this is found, it will be displayed in a dialog as shown in Figure 1. Please tap on the proper entry (which in most cases is the one with the highest signal strength) to complete the connection process. Now the flashing on the ErgoPen Neo should change to a steady blue light, and a moment later, the icon for the connected pen will appear in the upper left corner of the screen of the ErgoPen Neo app, along with the pen name. Now App and ErgoPen Neo can work together.

In all subsequent cases the pen will immediately connect with the app when both are switched on until the pairing has been removed.

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[1] Oviatt, Sharon; Cohen, Adrienne; Miller, Andrea; Hodge, Kumi; Mann, Ariana: The Impact of Interface Affordances on Human Ideation, Problem Solving, and Inferential Reasoning. In: ACM Transactions on Computer-Human Interaction (TOCHI) 19 (2012), 10.

If the ErgoPen Neo app does not immediately find the ErgoPen Neo, it asks in the first dialog if you want to repeat the search (see also section 10.2 on page 35). Please check if the ErgoPen Neo flashes blue and is in the immediate vicinity of the tablet and repeat the search. The app works without the ErgoPen Neo, but then can not record new tests.

If you have switched the pen off and on again during operation and it should not automatically connect to the app after switching it on again, you can also start the connection process yourself in the pen settings dialog. You will find more details in section 8.1 on page 28.
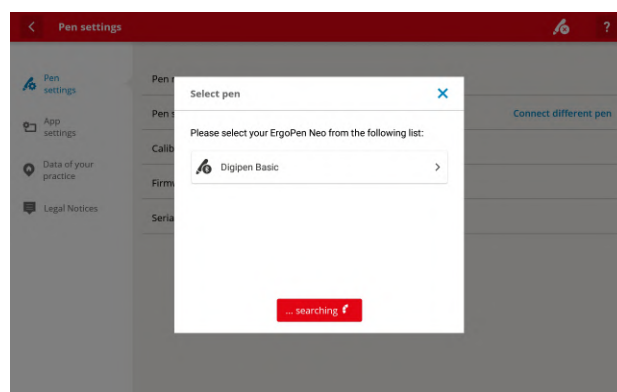
Figure 1: List of connectable devices with one entry

3.5 Remove pairing

To disconnect a pen that is paired with your tablet device, you can either use the preferences of the ErgoPen Neo app or the settings menu of your tablet OS. This should only be required if you want to pair another pen with the app while the already paired pen is switched on. In single pen operation, unpairing is not necessary. In the ErgoPen Neo app, please go to the Settings section and select Pen Settings there. On the right side of the Pen Status line, please tap CHANGE PEN and then tap the blue ✖ in the pairing dialog that now appears and confirm that the app will now continue without a pen.

In the tablet's settings menu, select the Bluetooth entry on the left side and in the MY DEVICES list on the right side, select the line where the pen you want to disconnect is displayed. There please tap on the blue ⓘ and then on Ignore this device in the window that appears.

3.6 Regular use of pen and app

Using the app follows a simple pattern which is outlined below in five easy steps.

Step 1: Charge your pen using the USB cable provided via a computer or the charger. The charging time is approximately 4 hours. The LED lights up green as soon as the battery is fully charged.

Step 2: Switch on your pen by pressing the on/off switch for about one second. The pen will immediately start flashing blue and is ready to connect. If the pen does not switch on, try to keep the on/off button pressed down for longer. If the pen does not switch on even after 2 seconds, connect the charging cable and charge the pen for at least one hour. If all does not help, please consult section 10.1 on page 35.

Step 3: Now start the corresponding app on your tablet. Follow the instructions on the screen.

Step 4: Connect the pen to the app. After successful connection, the LED lights up solid blue. Please note: The sensors in the pen must be calibrated from time to time. The app will inform you automatically. Please follow the instructions in the app. The calibration takes about 3 minutes.

Step 5: To switch off the pen, press the on/off switch for approx. 1.5 seconds until the LED goes dark.

Please connect your tablet to the Internet at regular intervals to check for app updates. This will keep your app and pen up to date.

4 Taking care of your ErgoPen Neo

4.1 Switching the pen on and off

To switch the pen on, press the round, blue button on the top between grip zone and logo for at least a second. Success is signaled by a quick double blue blinking of the LED which indicates the boot procedure.

In order to switch the pen off, press the round, blue button on the top between grip zone and logo for at least 1½ seconds, until the LED goes dark.

4.2 Pen charging

Your ErgoPen Neo contains a high-quality, rechargeable lithium-ion battery that should be charged regularly. To do this, open the flexible lid at the end of the pen and insert the supplied USB-micro cable into the socket provided. Please connect the other end of the cable to the supplied charger, which you plug into a power outlet. In principle, you can charge the pen at any USB port that provides at least 100 mA and up to 1000 mA of power, but we recommend that you use the included charger. As long as the battery is not fully charged, the LED on the lower side glows orange. This light turns green when charging is completed.

Figure 2: Insertion of the USB cable

After about 3 to 4 hours, a completely discharged battery is fully charged again. This allows the pen to be operated for at least 15 hours.

4.3 Connecting the pen

An already paired pen will connect automatically if both pen and app are switched on and in range of each other. Connection can be forced by chenging in the pen settings menu of the app as expained in section 8.1 on page 28.

4.4 Disconnecting the pen

In order to disconnect a pen from its Bluetooth link with the tablet, simply switch it off or select the menu item CONNECT DIFFERENT PEN in the pen settings menu of the app as shown in section 8.1 on page 28.

4.5 Changing the ink cartridge

If the writing tip dries up, you will find a replacement insert in the packaging. STABILO also offers a pack of four replacement inserts for the ErgoPen Neo. Please do not try to replace the insert with a commercially available ballpoint pen refill - the insert of the ErgoPen Neo was specially developed for it.

To replace an empty insert, the grip zone part can be pulled forward and releases the insert, which can then be easily replaced.

To assemble the pen, please proceed in reverse order. Please make sure to slip the grip zone part onto the pen shaft in a straight way and not to rotate or twist it.

(a) Pushing with two thumbs   (b) Pulling off in forward direction
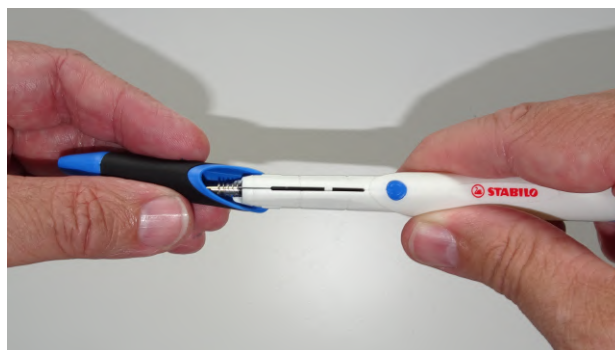
Figure 3: Removal of the grip zone part

4.6 ErgoPen Neo calibration

The ErgoPen Neo contains extremely sensitive motion sensors that need to be re-calibrated from time to time. When you first start using the pen, the ErgoPen Neo App prompts you for this calibration because no accurate measurements are possible without current calibration data. If you see a dialog similar to the one in Figure 4, tap on OK and in the next dialog tap on Calibrate pen. After that, please carefully follow the instructions on the next screens. The calibration process goes through two steps: First, the zero points of the rotation rate sensors are measured (see also Figure 5a), then the magnetic sensor in the earth's magnetic field (Figure 5b). While the pen should be immobile in step 1, in the second phase please rotate the pen around all axes so that it points in as many directions as possible when you are done.
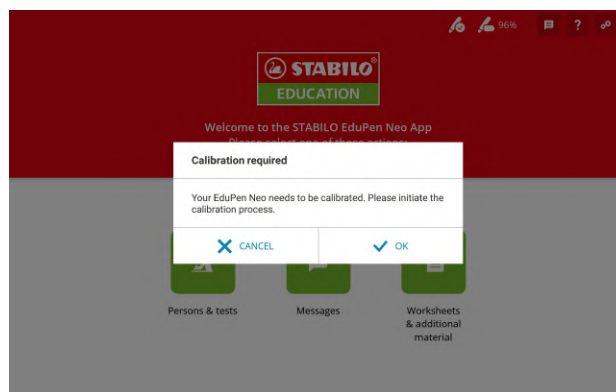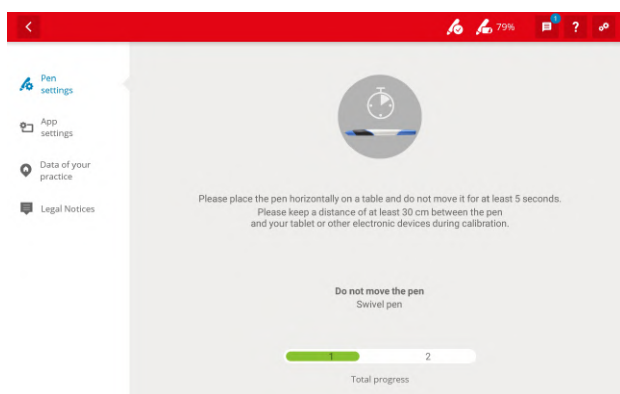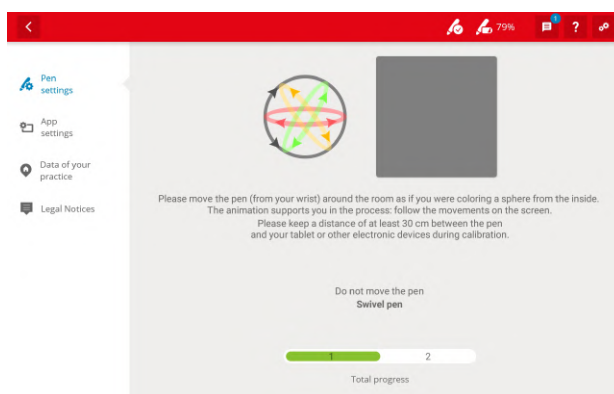

Figure 4: Dialog box for pen calibration

Note: When calibrating, keep a sufficient distance (at least 30 cm) between the pen and the tablet, because the magnetic field of the tablet can falsify the sensor data of the magnetic sensor.

(a) Calibration of the gyro sensors   (b) Calibration of the magnet sensor

Figure 5: Pen calibration

If you move the pen too little or only in one direction, the green progress bar will fill more slowly. If there is then still too little alternation in the direction of the pen tip, try to twist the pen as well. This will allow the pen to point in all possible directions straight up as well as upside down, improving the calibration result.

4.7 Firmware update

STABILO is continuously improving both the ErgoPen Neo App and the software which runs inside the pen. Therefore, it is likely that a new version is available when you receive your pen. The software controlling the processors inside the pen is called firmware. Pen and app work best together when the latest firmware version is installed. Each time when you have received an update for the ErgoPen Neo App, please check whether a firmware update is available. This can be done in the pen settings menu which you reach by tapping the symbol ⚙ which is located at the far right of the title bar of all screens.
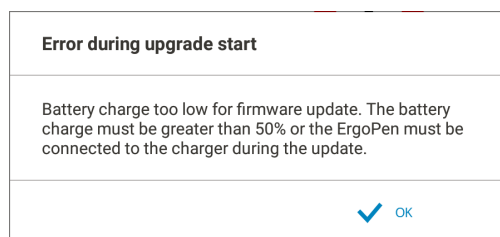
Figure 6: Alert in case of too little remaining battery charge
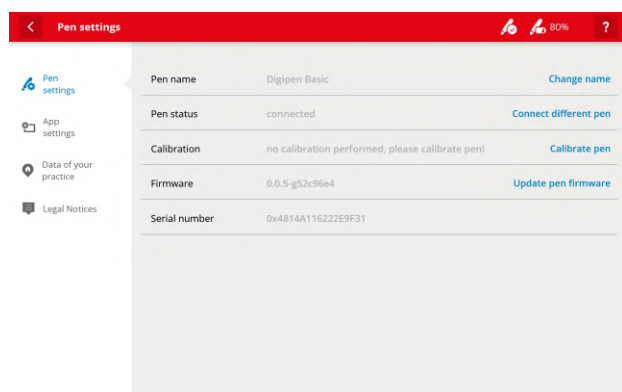
(a) Calibration and firmware update required
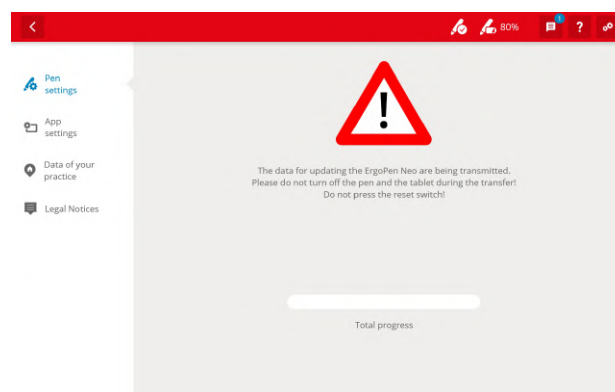
(b) Update in progress

Figure 7: Pen settings page for a pen with old firmware

Next, select **Pen Settings** and make sure the pen is connected with the tablet. Then the screen should look like in Figure 7. Figure 7a shows the case that all is well and Figure 7b shows the screen when a pen in need of an update is connected.

To start the update process, the pen must be connected with a remaining battery charge of at least 50% (see Figure 6 for the warning dialog when the battery level is too low). When you tap on **Update Pen Software,** the pen will start to blink purple. Please place the pen next to the tablet and let the update procedure run its course. It will take several minutes and will reboot the pen when finished. After the reboot, which is indicated by two blue LED flashes, the pen will start to blink blue and will connect with the tablet again. Now it can be used normally again.
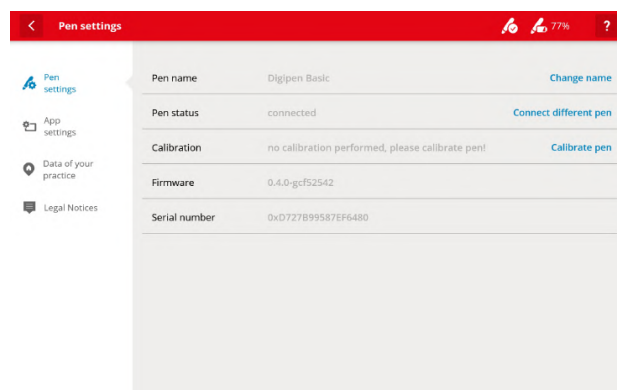
Figure 8: Successful conclusion of the firmware update

4.8 Remove Pairing

To disconnect a pen that is paired with your tablet device, you can either use the preferences of the ErgoPen Neo-App or the settings menu of your tablet OS. This should only be required if you want to pair a diferent pen with the app while the already paired pen is switched on. In single pen operation, unpairing is not necessary. In the ErgoPen Neo-App, please go to the Settings section and select Pen Settings there. On the right side of the Pen Status line, please tap CHANGE PEN and then tap the blue in the pairing dialog that now appears and confirm that the app will now continue without a pen.

Alternatively, in the tablet's settings menu, select the Bluetooth entry on the left side and in the MY DEVICES list on the right side, select the line where the pen you want to disconnect is displayed. There please tap on the blue (i) and then on Ignore this device in the window that appears.

To even remove all bonding information on your pen, keep the on/off-switch pressed for at least 10 seconds when switching the pen on. A double violet blinking will confirm a sucessful removal of the bonding information.

5 The ErgoPen Neo App

5.1 Launching the ErgoPen Neo App

You start the app by tapping on the icon shown on the right. If it is not in the list of apps installed on your tablet, please download the ErgoPen Neo app from the Google Play Store or the Apple AppStore. For the hardware and operating systems minimum requirements please see section .

5.2 Start screen: The principal functions of the app

At startup, the program first tries to establish a connection with the pen. If the pen is switched on and nearby, click on the leftmost symbol shown in Figure 9a and this will be done automatically. Now the pen will be listed with its Bluetooth name in a dialog box. Touch the name entry to confirm the connection. If several non-linked pens are nearby and turned on, they will all appear in this list at the bottom of the dialog box. Please select one by tapping on its entry. If no pen could be found or none from the list was selected, the app will report this with a dialog like the one in Figure 9b and offer to continue without a pen.
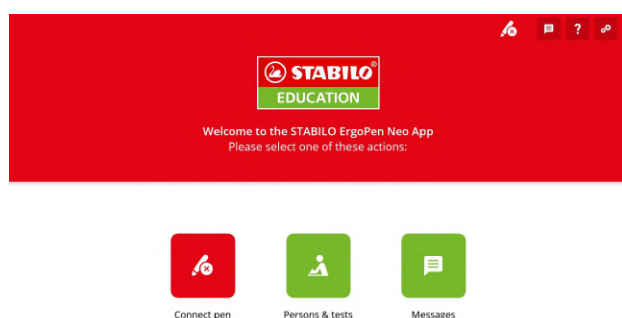
(a) Launch screen on first startup	(b) Home screen when no pen could be found
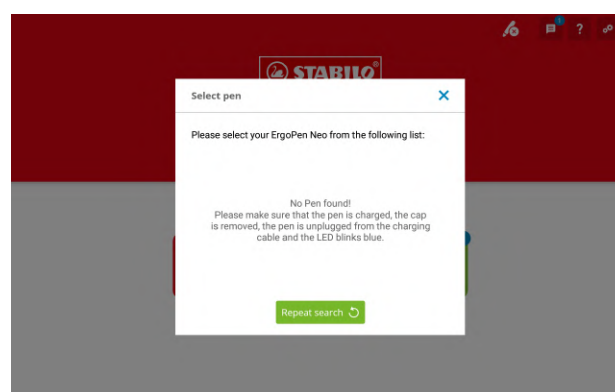
Figure 9: The ErgoPenNeo-App on launch

The start screen after connecting to the pen is shown in Figure 9b. If the pen is not connected, it looks the same, only the left icon is still visible to start the connection process manually at a later time. The meaning of each symbol is:

Connect pen: Tapping this symbol allows you to connect a ErgoPen Neo with the app.

Persons & tests: Jump directly into the database and enter group and client data. Continue to tests if a pen is connected. Continue in chapter 5.3.

Messages: Here you receive messages, regarding news to the app or updates. If you can't see any messages, the function must be activated in the settings.

5.3 Client list

Figure 10: Client list

At the bottom of the Master data screen some diagnoses are readily prepared, so you can assign them to the patient by tapping the respective checkboxes. If you would like to add a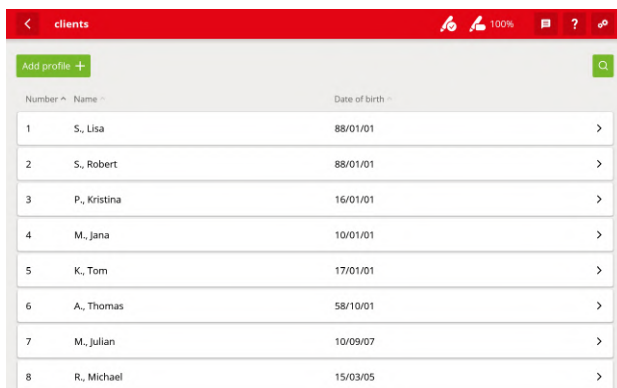 diagnosis that is not listed there, please use the entry remarks / key words to be able to enter free text via the on-screen keyboard that appears.

To display all of the screen, you will need to swipe in a vertical direction to scroll down.

There are various options for editing:

Edit: tap into the corresponding line in order to enter text with the help of the virtual keyboard.

Edit date of birth: To set the date of birth, please tap on the calendar symbol ▦ next to it. A calendar opens in Month view to select the birthday and month. To adjust the year, please tap on the small year in the colored box and select the year by swiping in the white box. Then please confirm with OK. The date of birth is important so that the appropriate reference data for the respective age are used.

Checkboxes and radiobuttons: Tap to select the appropriate option.
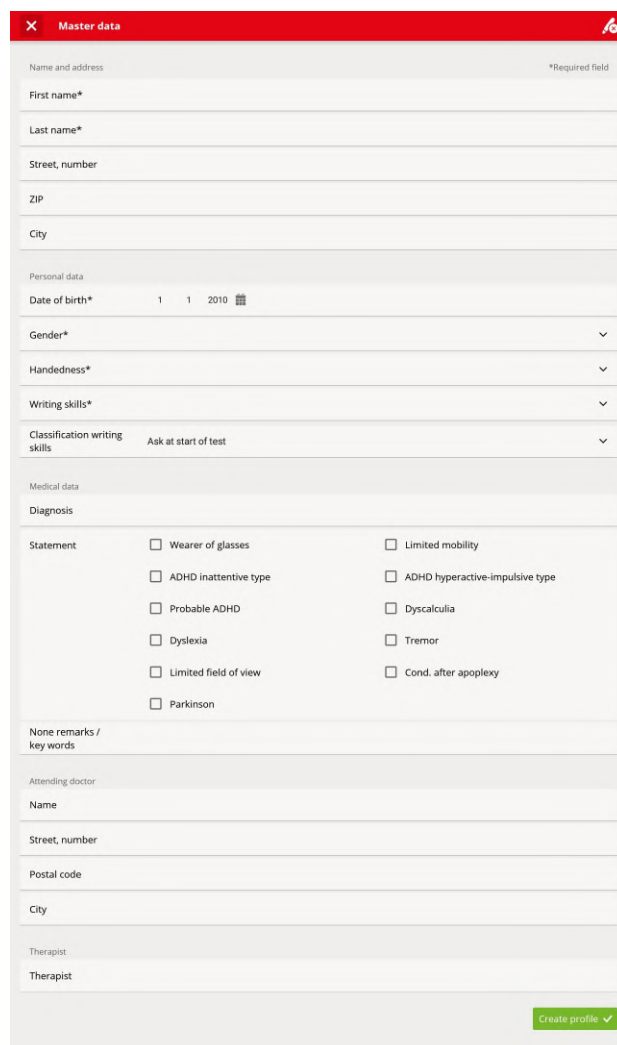
5.4 Messages

To access your messages, press the corresponding icon. Here you can view all your current messages sorted by date (see Figure 12a on the next page). You will receive information about updates and innovations, tips on use or news about new exercise opportunities or training offers from STABILO Education. If the messages are not displayed, they have been deactivated in the settings. To activate the messages, please go to Settings - App Settings and set the messages to activated (see Figure 12b on the following page).

Tapping on the button marked Persons & tests on the start screen brings you to the list of clients. See Figure 10 right for an example.

Create a new client entry

You can open a dialog to add a new client to the client list by tapping on the green plus sign above the patient list. The creation of a new patient requires that at least the five mandatory fields marked with an asterisk (first and last name, date of birth, gender, handedness) be completed. Figure 11 shows the complete list of possible entries.

Figure 11: Master data entry dialog
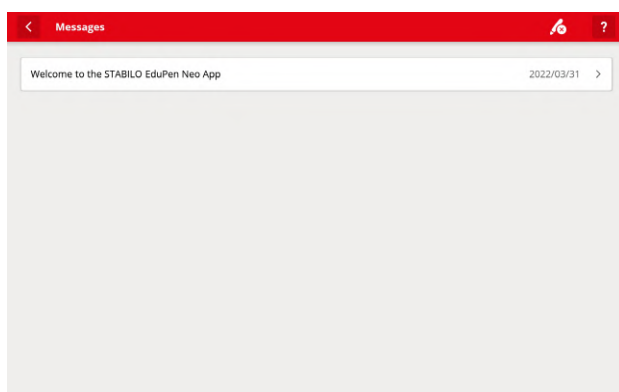
(a) Message list with a single entry   (b) App settings dialog with Messages enabled
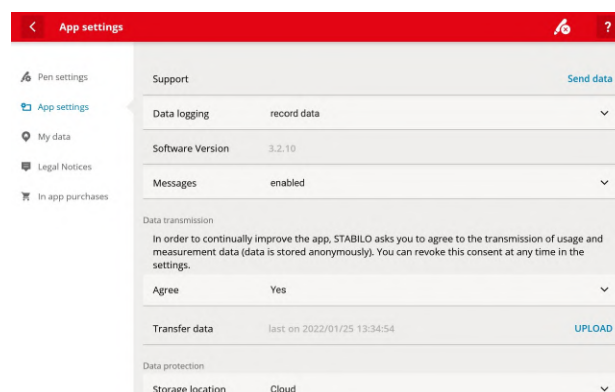
Figure 12: Messages

5.5 The title bar

The red title bar has a button on the far left that takes you back to the next higher-level screen. This is followed by the client name who's data is displayed or no entry for general content.

On the right, depending on the status of the pen, there is an icon that shows a connected pen and its remaining battery charge or an icon that indicates that a connected pen is missing. On the far right there are buttons for the help function, messages and for the settings screen (see Chapter 8 on page 28 for more).

5.6 The navigation column

Once a client has been selected in the Persons & tests branch, the column on the left side of the screen gives access to personal data in five groups. The symbols in the left column mean:

Tests Here you can view the result sheets of past tests and start new ones. For details see section 8.1 on page 28 below.

Reports Here you can access or generate test reports. For more information see section 8.3 on page 30.

Live Feedback Here you have the opportunity to practise writing and grip pressure in a playful way. See section 7 on page 26 for details.

Material Current material recommendations for occupational therapy and for home, as well as pencil recommendations can be viewed here. In addition, basic information on writing and graphomotoric skills and their further literature can be found.

Master Data This gives access to the profile data of the selcted client.

6 Testing

6.1 Starting the test

Once a client has been slected, a test can be started by tapping on the **Start new test +** button on the top left corner of the test list. The test list can be reached by tapping on the first symbol in the row on the left.

Figure 13: List of previously performed tests

6.2 Test tasks

The test is divided into individual tasks for writing and graphomotor skills. Depending on how the client's writing ability is rated in the profile data, certain tasks are added or omitted. If a client is able to write, the test contains all 10 tasks. If a client can only write single letters, the first task is omitted. If a client cannot write yet, all writing tasks are omitted so the test contains only 5 tasks. The blue rectangle in the upper half of the test screen is used to display the task and to navigate between tasks. Below this, observations can be recorded by selecting pre-made entries.

The row of circles above the task description shows which task has already been processed and which is currently active. An open circle stands for a task that has yet to be processed, a green circle for a correctly processed task and the circle for the currently active task is filled in white. As you edit, the row of circles will be hidden to minimize distractions.

Below the task description there are buttons that display a sample video or start the measurement. The button that should be pressed next during the normal course of the test is always highlighted in green. Left and right are buttons to move to the previous or next task. Once a task has been processed, the right button is highlighted in green to indicate the next step. If you want to discard or repeat the recording of the current task, you can easily do this by pressing the corresponding box. Then you have the option of repeating or skipping it.

(a) The first task of the test is about to commence   (b) Hatching task running with selected observations
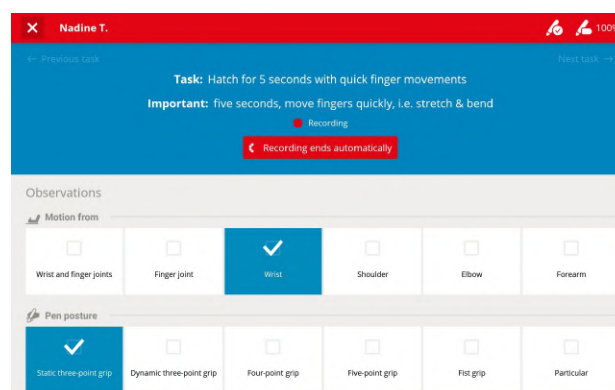
Figure 14: Different screens during the process of testing. Left: Test before start; Right: Task in progress.

For tasks that require a certain amount of time to be worked on, a progress indicator is started when the pen is put down, in which a circle gradually fills. When the circle is full, the required duration has been reached and the task ends automatically (Figure 14b). To do this, simply press **Start measurement**.

After the last task the button **Next task** -> changes to **Conclude test** and a new dialog appears after the button has been pressed which asks the teacher to judge the legibility of the client's handwriting (see Figure). Since this requires a subjective judgement, the teacher's assessment is adopted here. The screen then switches to the display of the test results (see section).

6.3 List of test tasks

Table 1 lists the separate tasks in the sequence as they are presented by the app.
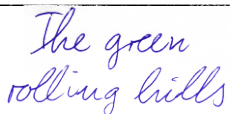
	Instruction	Example	Remarks
1	Write your own name		Start before the pen touches the paper, stop when the client has finished writing.
2	Write in your personal handwriting the sentence "The green rolling hills"	*The green rolling hills*	
3	Write in large block letters the word „BUNNY"	BUNNY	Alternative task for clients who cannot write the sentence.
4	Write in your personal handwriting five times the syllable „ele"	ele ele	right-oval letters
5	Write in your personal handwriting five times the syllable „ana"	ana ana	left-oval letters
6	Hatch for 5 seconds with quick movements from the wrist		Start before the pen touches the paper. Do not set down the pen, but keep it continuously on the paper.
7	Hatch across it for 5 seconds with quick finger movements		
8	Spin circles for 5 seconds with fast movements on the spot		
9	Draw three standing arches, five times in a row	m m	
10	Draw three hanging arches, five times in a row	uu uu	

Table 1: The tasks of the test

The test procedure and the scope of tasks should be adapted to the possibilities of the client. For example, if the clients cannot write yet, they will work on tasks 6-10. If the clients can write first letters, they will work on the test tasks 1, 3, 4, 5, and 6 to 10.

If individual tasks are omitted, some of the evaluation diagrams which summarize results from several tasks can no longer be meaningfully interpreted and are not displayed in the evaluation. In any case, individual evaluations are included for each task, so that the completion of only a single task already leads to a valid, albeit limited, test result. For more information see section .

In the test tasks which ask for a pattern to be repeated five times (these are numbers 4, 5, 9 and 10), of all parameters only the duration is affected if not exactly five patterns are written. With only four or

fewer patterns, the duration is shorter than in the reference data and longer for six or more. Force, speed, frequency, degree of automation or writing angle are mean values over all patterns and do not change with their number.

Note: Even though the exercises are intended for cursive, the test may also be completed in block letters if the usual handwriting of the client in everyday life is in block letters. The reference data was also collected according to this philosophy.

6.4 Parameters used in the test result

The custom software for graphomotoric evaluation identifies five parameters from the pen data which are explained in detail below. By performing standard methods of signal processing, other parameters can be identified as well with different software.

Duration

Meaning: writing time from the first touchdown to the last lifting of the pen.

Background: The pressure sensor installed in the pen detects when the pen touches the first and last time during a test task. This period is stopped and output in milliseconds [ms]. The duration gives information about how long the execution of a test task took. This parameter differs from the writing frequency and the writing speed, since the write pauses are also included here. An increased number of write pauses indicates problems with the writing process.

Pressure

Meaning: The average vertical force with which the pen is pressed onto the paper surface.

Background: The force sensor built into the pen records the axial force in Newton [N] that is applied to the paper during writing. The measuring range is between 0 and about 5.3 N. This axial force is then combined with the writing angle to result in the vertical writing pressure. A low writing pressure for an adult is a little less than 1 N (Newton = force unit = about 100 g). An increased writing pressure is displayed starting at 1.5 N. The writing pressure is usually measured when writing a sentence, rather than simply repeated movements (for example, a donut).

Speed

Meaning: The average absolute speed of the pen on the paper.

Background: By calculating pen positions on paper, the distance traveled can be determined. If this path is then set in relation to the required time in which the pen is on the paper, the writing speed can be calculated in millimeters per second [mm/s]. The writing speed is usually also dependent on the writing size - the larger the writing, the faster the pen is moved. However, low writing speed also indicates problems with adequate muscle activation or problems with inadequate automation of the writing process.

Frequency

Meaning: The number of strokes on the paper per second.

Background: The writing frequency is a measure of the movement frequency during writing (up and down movements) and is given in Hertz [Hz]. Movements in the air are not counted. A writing frequency of 5 Hz (Hertz = cycles per second) means that the pen is moved up and down 5 times per second and then 100 ms are required for each single stroke. The writing frequency is a stable measure of motor writing power. Experienced writers write with fast automated movements and a frequency of 4.5 to 5 Hz. Here, the hand oscillates in the horizontal around the wrist with its eigenfrequency, which is determined by the mass of the hand and pen as well as the muscle tone. This movement is the slower, the more the writing movement must be corrected due to lack of routine. Writing beginners or learners have yet to develop a sense of the power with which a pen must be moved to achieve a line of a certain length. Therefore, their writing movement is subject to noticeable visual monitoring, especially when they have to write within given lines. This leads to corrections within a stroke, which takes more effort for a given writing movement and takes longer. This duration is measured by the Digipen and expressed in terms of the writing frequency.

Simple letters (e.g., script-ℓ) can be written with a simple up- and downstroke. For example, more complex letters (e.g., script-g) may require 2 pairs of strokes. Depending on the complexity of the letters used, the same writing frequency may result in different writing speeds, depending on the letters written.

Automation level

Meaning: The degree of automation of the writing movement counts the number of changes of direction in the speed per stroke (Number of Inversions in Velocity, NIV).

Background: A movement execution is always described as automated if there are smooth and single-sided (bell-shaped) velocity profiles for each movement segment (stroke; see [**?**]). The movements are then always executed without interruption in one go. As a quantitative measure of the degree of automation of a movement, it is useful to calculate the number of inversions in velocity (NIV) for each stroke, which corresponds to the number of sub-movements used per stroke. Learned movements are carried out automatically, that is, completely pre-planned and then and no longer consciously controlled or controlled in detail. The advantage of automated movement execution, in addition to the high execution speed, that , is that the working memory is freed from supervising the motion and can, for example, focus on content or spelling. If, in the optimal case, the up or down strokes are carried out with one single movement, the result is a value of NIV = 1; non-automated movements result in larger NIV values.

Writing angle

Meaning: The mean angle between the longitudinal axis of the pen and the paper surface.

Background: With the help of the inertial sensors in the pen, the angle can be recorded during writing. A pen that lies flat on the paper has an angle of 0°, and a pen that stands vertically on the paper has an angle of 90°. The pen should not be held too steeply when writing, but not too flat as well. A writing angle of about 50-60 degrees is considered optimum. A medium pen angle in conjunction with the finger joints in a middle position allows a high freedom of movement for small-scale motorics, which is important for a good shape of the letters. A too steep pen angle is often associated with reduced finger agility and cramped gripping position, and greater forces must be applied to guide the pen. Furthermore, the hand transport can be difficult when the wrist is lifted off the paper.

6.5 Test results

After the last task, the test can be completed and an evaluation as shown in Figure 15a is displayed. Test results a green shading to convey the performance relative to reference data from the same age group: While the green areas show age-related good performance, readings in the grey areas are grounds for recommended exercises. Besides the results of the test just performed, also the results of the previous test are displayed (if available) to immediately show the progress since last time. As the example shows, while the grip pressure has only marginally improved, the writing pressure are has moved into the center of the age average.

At the bottom of the page the observations made during the test are shown; also, the app allows to take a picture of the test sheet to aide in memorization (see Figure 15b).
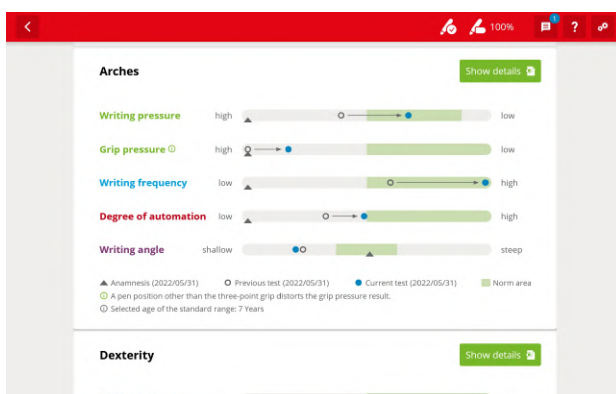
(a) Display of test measurements (excerpt)
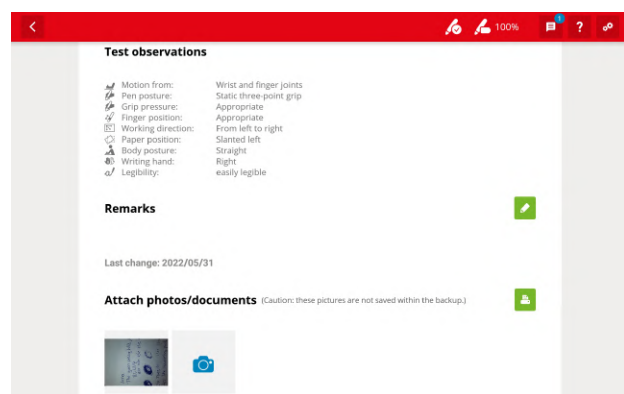
(b) Additional remarks and photo

Figure 15: Display of test results after conclusion of a test

6.6 Test report

To communicate the test result and further actions to the client and his parents, the program issues a test report that can be exported as a PDF or printed. An example of such a report is shown in Figure 16.

6.7 Hints for Testing

Position and Writing Pad

For right-handed clients, a position of the therapist to the left of the client is recommended; for left-handed ones a position to the right. This makes it easier to observe the client during the test procedure. Please also make sure that the supporting hand of the clients do not obscure the word they are to copy; especially smaller clients want to check what to do several times within a task. Alternatively, you can have the instructions on a second sheet, so you do not have to restrict the position of the supporting hand.

In order to ensure an optimal comparability of the data with the reference data, there should be at least 5 more sheets of paper stacked below the test sheet. With a test sheet lying directly on the table (ie without more sheets below it), a higher writing pressure is to be expected.

Demonstrate Tasks

Especially the hatching tasks benefit from being explained beforehand. Either do it yourself, or use the function **Show example ◉** that displays an endless video of the task.

Quality of the results

Figure 16: Test report

When evaluating the tasks, the app assumes that the work is done in a diligent and correct way. Spelling and calligraphy are not evaluated; the measurement is primarily about the degree of automation of the handwriting and the age-appropriate development of fine motor skills. Therefore, the app will not complain if anything other than the default text has been written, but the reliability of the evaluation will suffer from a negligent performance. Therefore, as a test supervisor, you can directly influence the quality of the tmeasurements by monitoring the processing of the tasks and by letting the client repeat them if there are any shortcomings.

6.8 Privacy protection

The client data and the graphomotoric data collected during the test represent personal data that should be protected against unauthorized access. The data collected by the app are in detail:
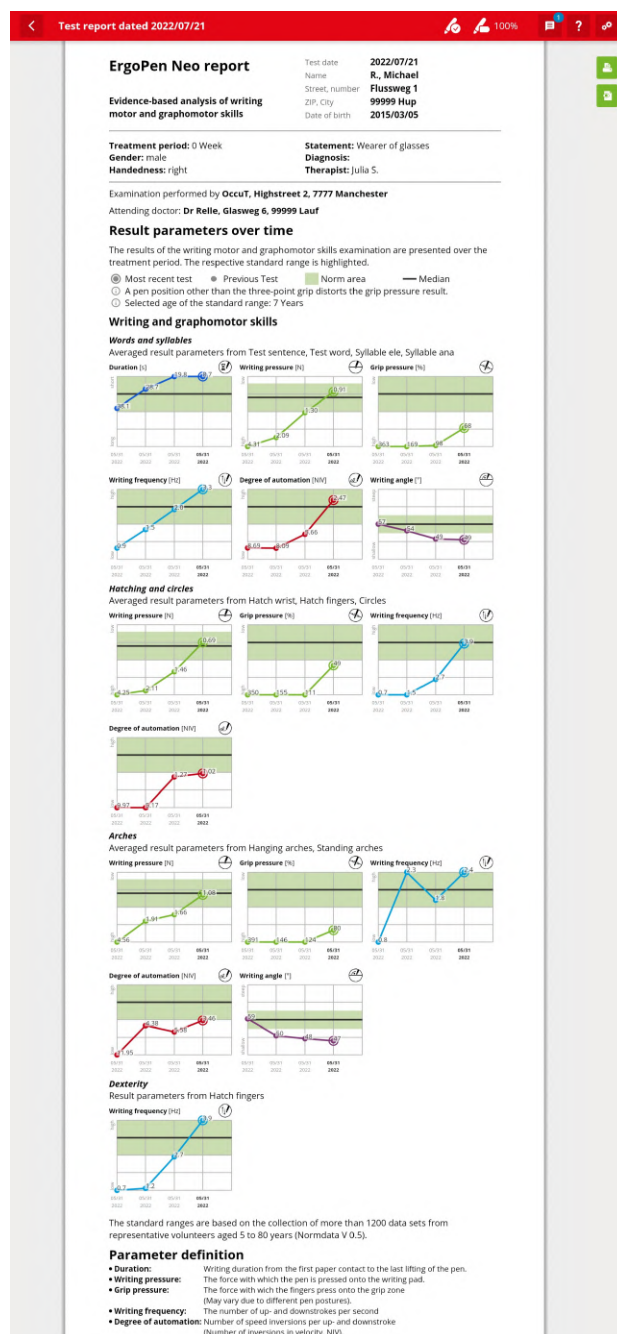
- All personal entries in the client master data page.
- The results of the evaluation of the sensor data for each section of the test by the app.
- If the checkbox for **Record ErgoPen Neo sensor data** is set in the app preferences, all raw sensor data corrected by only the calibration data is collected in a separate directory in the tablet. This function is for collecting reference data and should normally be unchecked.
- The reports in PDF format.

All collected data is stored locally on the tablet and it is the responsibility of the teacher to give access to the tablet data only to authorized persons. Therefore, we recommend restricting access by assigning a lock code to the tablet.

Therapists can enter their personal and their practice data in the **My data** section in the settings area (accessible via icon ⚙ in the top right corner) so it will show up in the results reports. All data collected by the app is stored locally on the device. Especially in case of iOS, this means that all data will be lost if the ErgoPen Neo app is de-installed.

You will also find a checkbox that allows you to give your consent to the transfer of usage data to a secure STABILO server. The information transmitted from the ErgoPen Neo app to our server will be encrypted and is only saved in anonymized form, so it does not allow any conclusions to be drawn about the people involved. This data helps STABILO to understand how often the app starts, when errors occur, which errors occur and details on the sequence of operations before an error occurred. This will help us especially to identify frequently occurring errors at an early stage, to analyze operating errors and to continuously improve the app.

6.9 Transfer of App Data

If you want to replace your tablet with a new one, you can transfer the data stored in the ErgoPen Neo app to it by making a backup copy, transferring this backup copy to the new tablet, and reading the backup copy after starting the ErgoPen Neo app. STABILO offers a cloud backup which is ideal for this purpose. Please note that importing a backup file will overwrite the existing database. Merging databases from two tablets onto one is not possible at this time.

Android

If you have a Windows computer handy, you can transfer the data to it (see section Copying reports to another computer below) using a program written specifically for this purpose, the STABILO Sync App. You can download the STABILO Sync App for transferring the ErgoPen Neo App test reports from an Android tablet here. This synchronizes the reports on your Windows PC with those on the tablet very easily and quickly.

If you are using an Apple® Macintosh®, Google offers a corresponding program for Android devices. It is called Android File Transfer and can be found on the internet at https://www.android.com/filetransfer/.

The program for the synchronization of reports between your tablet and your PC can be located anywhere on the PC and does not have to be specially installed. You can recognize it by the program icon, which is similar to that of the ErgoPen app (picture on the right).

When starting the program you will be prompted to connect the tablet to the PC. You do this with the USB charging cable, and after you insert it on your tablet, you see a message requesting permission to access the data on the tablet. Please tap **Allow** here. This will change the display of the synchronization program from the one shown in Figure 17a to the one in Figure 17b.

(a) Tablet not connected

(b) Tablet connected, ready to synchronize
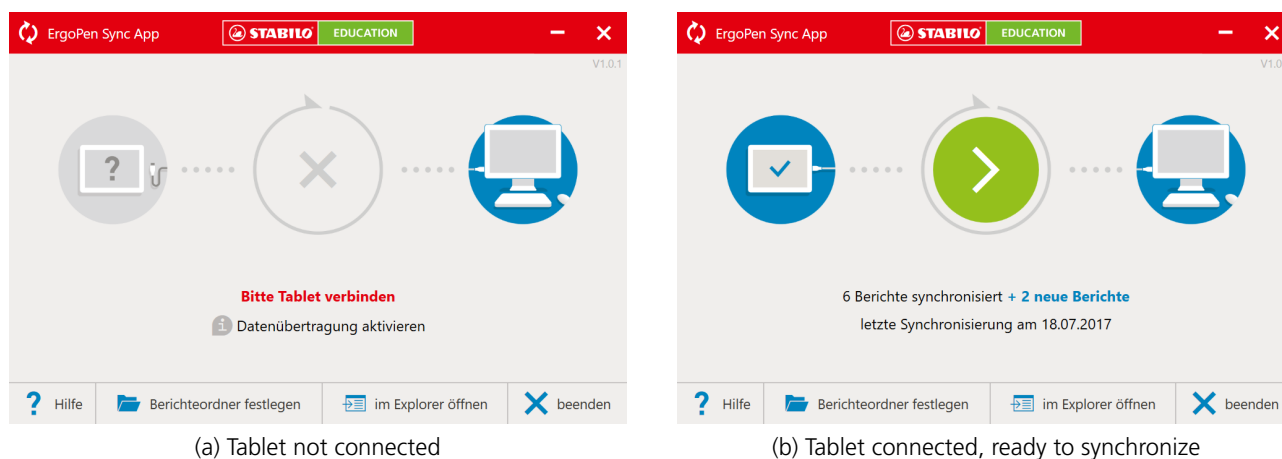
Figure 17: Synchronization software interface
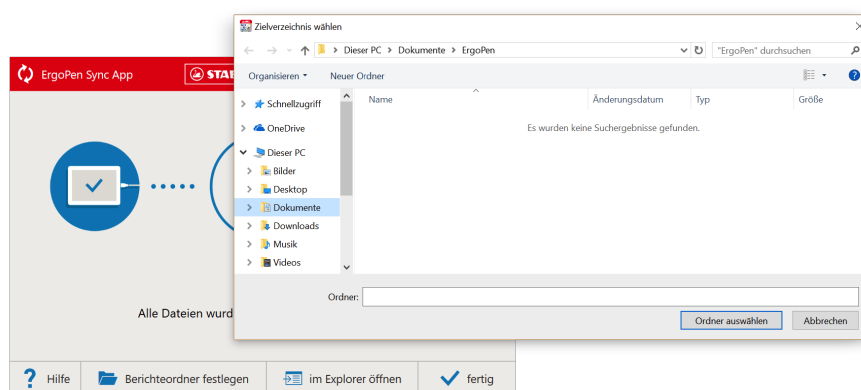
Figure 18: Determine the location of the report folder

Before you begin copying by tapping the green cir-
cle with the arrow inside, please check to which
folder of the PC file system the reports will be
copied.

By tapping on the command **Specify Report
Folder** you will open a file dialog in which you
can specify the destination folder on the PC. After
copying is completed, use the **Open in Explorer**
command to display the folder on the PC to which
the reports have been copied. A successful syn-
chronization is displayed with a matching icon in
the middle between the tablet and the PC symbols
(see illustration 19).

Figure 19: Successful synchronisation

Apple iOS

To make it difficult for other programs to access the ErgoPen Neo app data, the databases are all contained in a folder that only the ErgoPen Neo app can access. Therefore, we recommend using our cloud backup feature here.

Alternatively, if you have an Apple Macintosh with operating system version OSX 10.14 or earlier or a Windows PC, you can view the backup file via iTunes and copy it to the computer, then connect the new tablet and copy the backup file there via iTunes. As of macOS 11, if the iPad is connected to the Mac with a USB cable, it can share data via the Finder. If you want to transfer the data wirelessly, Apple offers synchronization via iCloud.

Please connect your Apple iPad to a computer via a USB cable and start **Apple iTunes**. In **iTunes**, open the iPad administration by clicking the tablet icon in the upper left corner of the screen. The small picture on the right shows this symbol encircled in red. If you use a Macintosh with macOS 11 or higher, open the iPad management in the Finder by clicking on the iPad icon in the left bar of the Finder window.
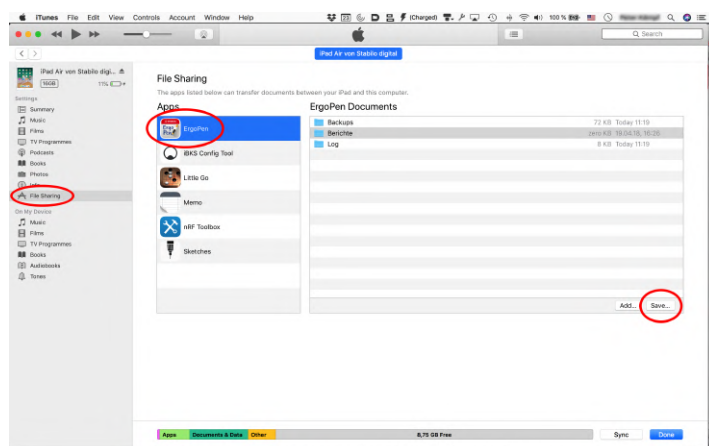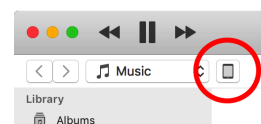
(a) iTunes window for reading the report files on a PC or Macintosh computer
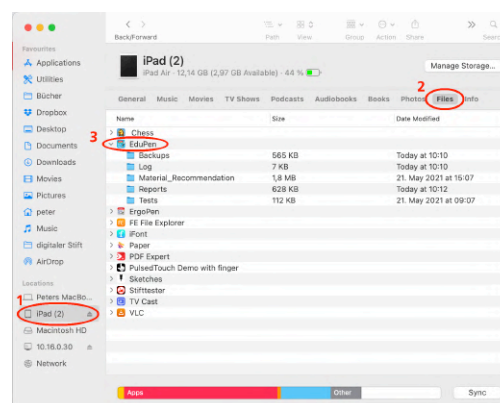
(b) Finder window with iPad files in macOS 11

Figure 20: Report synchronisation on an iOS tablet

In the view that then opens, please select the **Data Sharing** entry in the list on the left (circled in red in Figure 20a) and then select the ErgoPen Neo App in the middle column that opens as a result (also circled in red). This will bring up a list of file directories in the right column. The one named Reports contains all the PDFs and can be copied to the connected computer for synchronization simply by clicking **Save**. The folder named **Backups** contains all the backup files that you can use to restore a damaged database or transfer it to another device. In macOS 11 and higher, first click on the entry for the iPad in the left column, then on the icon of the app in the app overview that opens, and then on the Reports folder icon, which contains the PDFs of the reports. If the iPad should not be displayed, please check in the Finder settings if the checkmark for CDs, DVDs and iOS devices is set for the sidebar.

This opens a view like in Figure 20a. Select the entry Data Sharing (circled in red in Figure 20a in the list on the left side) and then the ErgoPen App (also in the middle column that opens; circled in red). This will cause a list of directories to appear. The one named **Reports** contains all PDFs and can be easily copied to the connected computer for synchronization by clicking on **Save** in the lower right corner.

After installation, please run the ErgoPen Neo app at least once to create the internal folder structure. For the details of accessing the tablet data, please refer to the following section on copying the data to another computer.

Dissemination of Reports via e-Mail   The app saves reports as PDF files, so you can print them or pass them on to your clients. Therefore, the name and address of your practive will also be requested in the settings, so that they can be included in the PDF. You can send messages directly from your tablet when you set up an email account. You can insert the reports as an attachment to these messages. In parallel to the report, a collection of all individual results will be saved in a second PDF file on your tablet. Alternatively, you can transfer the reports to another computer for printing or distribution.

Please refer to the section , because sending by mail uses the same mechanism as printing a file.

6.10 Printing the reports

All reports and exercise sheets are saved as PDFs and can be printed. The following section explains printing in Android, followed by the explanation for iOS. Both versions have the same entry point: In the report view, please tap on the green printer icon in the upper right corner (see Figure 21). Alternatively, you can export the reports and exercise sheets to another computer and print them from there. How to copy the files to another computer was explained in the previous section.

Figure 21: Printer symbol in the top right corner

Android   Since Android 8, you can print directly from the app. In older versions, you had to install a printer program from the printer manufacturer and select the document to be printed in it. To do this, please download the corresponding app from the Google PlayStore and follow the instructions of the printer manufacturer. In the printing app, you first need to connect to the printer. After that, you can select the report files and print them via the app. Usually, the app will offer a document folder called **Saved Documents** or **Documents**. In this, please open the ErgoPen Neo section. There you will find the sections **Backups** and **Reports**. In the reports section, you will find all the PDF files of the ErgoPen Neo app; please select the one you want and follow the instructions of the app to print it.

Figure 22: Android selection dialog

Figure 21 shows the report as it has been displayed since Android 8. Please note the green printer icon in the upper right corner, which is circled in red. When you tap on this, the selection dialog shown in Figure 22 opens first, in which please tap on the icon titled "**Print Service**". If you want to send the report as a PDF, you will also find a link to the mail program in this dialog.

In the dialog that now follows, you must select the printer (Figure , circled button in the upper right and bottom) and then, when it is connected and displayed, initiate the print command. In Figure this happens on a HP brand printer.
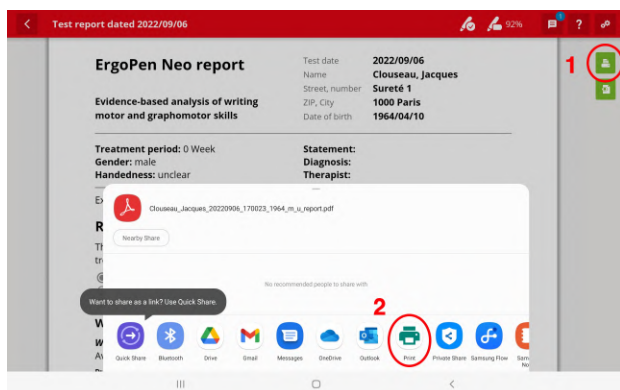
(a) Selection of the printer by tapping first on the top right (1), then on the bottom (2).
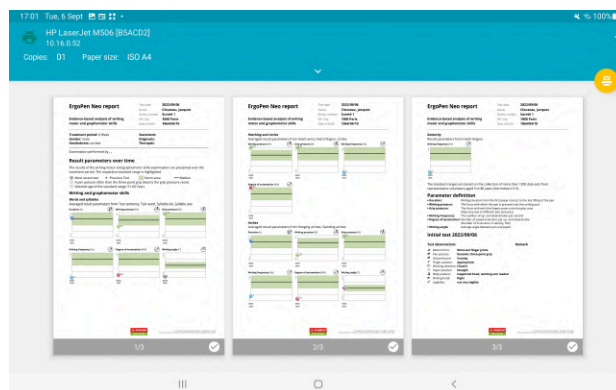
(b) Finally, the time has come: The report can be printed.

Figure 23: Printing a report in Android

Apple iOS   To print a report, tap the green Send Report printer icon at the top right of the page where the report is displayed. In Figure 21 on the preceding page this is circled in red. A window will open with a choice of options to share or print the report. Please tap on the printer icon in the bottom row (also circled in red in Figure 24) to initiate the printing process. This requires a printer that can be accessed via AirPrint over WLAN.

If you want to send out the report via mail, select the corresponding icon in the dialog shown in Figure 24.
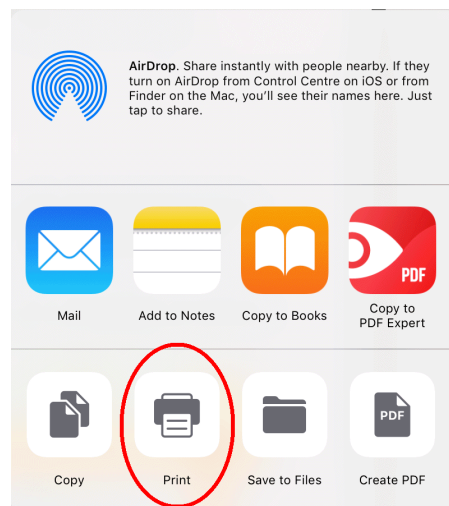
Figure 24: iOS selection dialog

7 Live Feedback

The live feedback is there to show the clients in a playful way when there is too much or too little pressure on the paper and / or the grip zone of the pencil. It can also be used as additional training units.

7.1 Exercise selection

You can choose from different playful tasks for grip or writing pressure and select the tasks to be worked on either individually or together by ticking them. You can choose between 6 different exercises for writing and grip pressure (see Figure 25a for a list). After you have selected the exercises, you can start the live feedback.

| (a) List of live Feedback exercises | (b) Hurricane exercise |
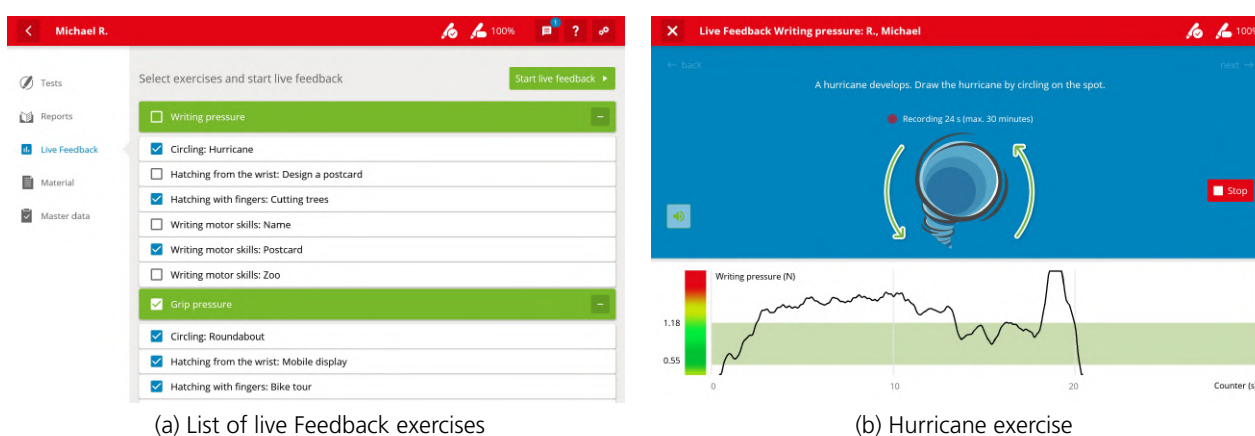
Figure 25: Live Feedback

7.2 Live Feedback Procedure

The execution is similar to the normal test. The upper blue menu part (see Figure 25b) navigates through the exercises and explains the task. You can also display an example again. Below the picture explaining the exercise, you can then see the scale from 'too little' to 'too much pressure', as also shown in the picture. This shows the current writing or grip pressure while performing the exercises and serves as a good demonstration in front of the clients. The measurement is made using the built-in sensors in the ErgoPen Neo. If the blue dot is in the green area, the pressure is good. If it is in the red range, the pressure is too firm. There is no

Figure 26: Live Feedback settings page

time limit for performing each live feedback exercise. To start the exercise, simply press **Start**, and to stop the exercise, press **Stop**. After completing the live feedback, simply press **Finish** on the last exercise. After finishing the live feedback, an evaluation is generated.

You can also set the timer individually for every task (Figure 26). The set time is retained for subsequent tasks. Longer time units are suitable for the fatigue test and writing training; shorter time settings such as 30 seconds are sufficient for a short demonstration. The recording stops after the specified time. You

can also set a longer time and stop the recording manually. Additionally, you can turn on the sound to hear when the normal pressure range is left and the force becomes too hard without having to look at the display. You can turn the feature on and off via the small speaker icon 🔊 on the left of the blue box. The volume is controlled by the tablet volume.

After completing the live feedback, simply press "Finish" on the last exercise. After finishing the exercise, an evaluation will be created. This evaluation is saved so that you can always look back on it and see the progress.

| (a) Overview of processed tasks | (b) Graphical representation of the process |
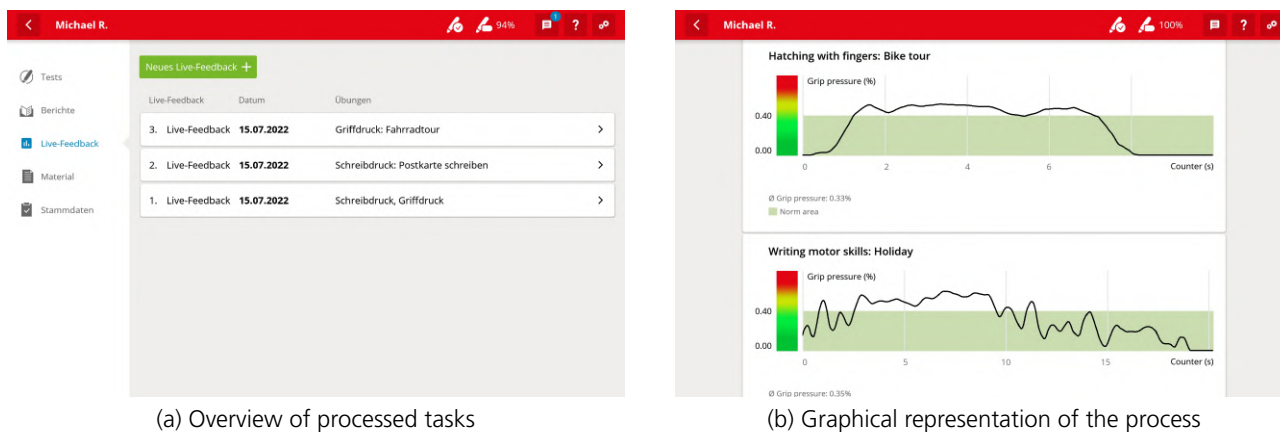
Figure 27: Evaluation of grip pressure and writing pressure

7.3 Tips for Live-Feedback

See chapter on position and writing pad.

8 Settings

Tapping on the Settings icon (⚙, located in the top bar on the far right) takes you to the Settings menu. If no client is selected, it allows to adjust application-wide settings in four groups. The symbols in the left column mean:

Pen Settings Here you can view or adjust settings for the ErgoPen Neo. For details see section 8.1 below.

App-wide Settings Here you can view or adjust settings for the app. For details see section 8.1 below.

My data Here you can enter or change the name and address of your practice. For more information, see section 8.3 on page 30.

Legal Notices Here are the imprint, the links to the privacy agreement and the licenses to the software libraries used in the app.

8.1 Pen settings

In this window, the name of the currently connected pen is displayed in the first line. In the second line, the connection status is displayed on the left and on the right, this connection can be disconnected to connect another pen to the ErgoPen app. If no pen is connected, the connection process can be restarted here. The third line is used to calibrate the sensors, which can be started with the button on the right. In the fourth line, the firmware version running on the pen is displayed on the left and a new version can be written to the pen with the button on the right if necessary. Figure 28 on the left shows the window if everything is correct and up to date.
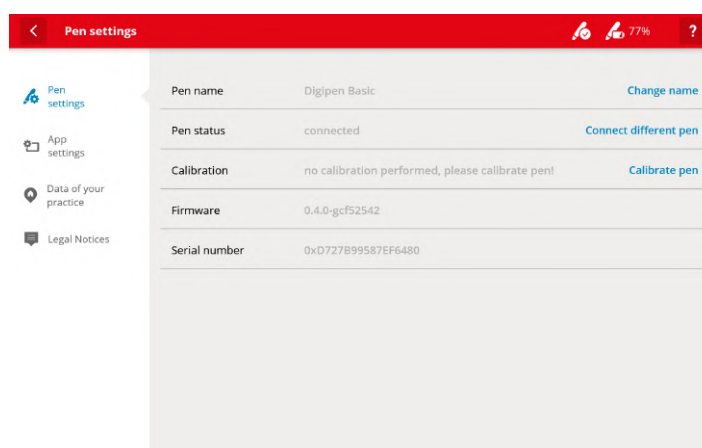
Figure 28: Pen settings

In both cases it is sufficient to tap the corresponding commands on the right side of the respective line to update. You will then be guided through the individual steps of the update procedure. Chapter 4.6 on page 9explains the calibration procedure while Chapter 4.7 on page 10 explains the firmware update procedure.

Calibration takes place in two steps: When the pen is connected, please place it horizontally at some distance from the tablet (see also section 4.6 on page 9). This serves to determine the zero levels of the yaw rate sensor. After a few seconds, you will be asked to rotate the pen in the air such that it points in as many directions as possible. You will see a red rectangle with a yellow dot in it which moves with the pen's orientation. The rectangle is representative of all the possible diections and will be filled with smaller green rectangles if magnetic measurements have been recorded in the corresponding direction. Section 4.6 on page 9 explains this process in detail.

Firmware is the software permanently installed on a device. STABILO always strives to improve it and, therefore, provides you with a mechanism to download the latest version onto your ErgoPen Neo. To do this, the pen must be connected and charged. Section 4.7 on page 10 explains this process in detail.

8.2 App settings
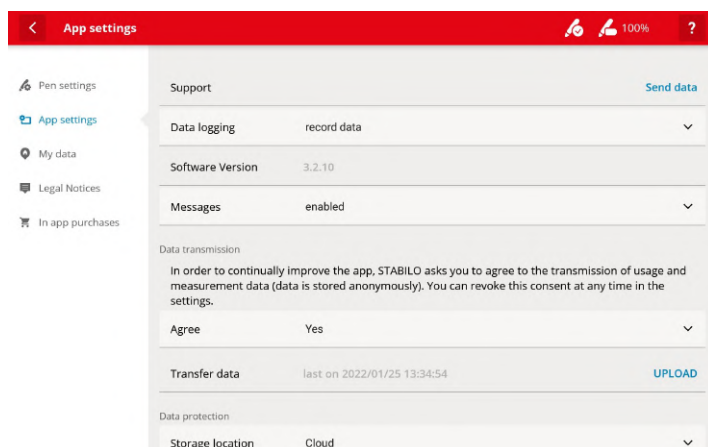
Figure 29: App settings

In the first line you can switch on the recording of the transferred data, which can be helpful for further analyses. For the analysis within the scope of the app this has no meaning.

This window is important because the second line provides information about the version of the ErgoPen app. If you contact STABILO with questions about the app, we will ask you about the version of your app. Ideally, you should look here before you make the inquiry and include the version number in your request.

In the middle of the window you can set whether usage and measurement data can be evaluated by STABILO. If you refuse your consent, all data collected by the app will remain on the tablet. If you agree, selected data will be encrypted and transferred anonymously to a STABILO server to help the developers to further improve the app.

In the bottom lines you can create backup files manually or restore a previous state by loading the backup file. These backups are stored locally on the tablet. If the tablet is lost or changed, they cannot be transferred to a new tablet.

Data backup

The ErgoPen Neo App offers several ways for backing up its data. Examples are:

1. Automatic backup on the tablet.
   The app creates backup files at regular intervals, which are stored in a separate directory in the tablet's file system. By tapping on RESTORE FROM BACKUP, you can call up an overview of the backup files and select one from them (see Figure 30 on the following page). The name suffix AutoBackup in the file name indicates whether this backup file was created automatically. After selecting one of the files, the current data of the app is deleted and replaced by that of the backup file. If you do not want to restore any data, tap the ✕ in the upper right corner.

2. Manual backup on the tablet.
   To create a backup file outside the automatic cycle, tap on the line CREATE BACKUP. This is recommended if you want to try something out and be sure to be able to restore the unchanged state of your data afterwards. In both cases, all data remains on the tablet. This carries the risk that if you lose the tablet or switch to a new one, all data will be lost. In order to be able to back up data to a second carrier, there is the option of exporting it by connecting the tablet to a PC or Macintosh (see section 6.9 on page 21). Alternatively, STABILO offers storage on a computer on the Internet, for which the third option is used:

3. Data backup in the cloud.
   This creates a compressed, encrypted and password-protected archive of your data on the tablet and uploads it to a server within the EU. When creating the archive, the app tells you a randomly selected identifier that you need in order to retrieve the data from the cloud later. Additionally, you will be asked to enter a password of at least 5 characters in length, which should also contain at least one uppercase letter, one lowercase letter and one digit.

Restore from backup   ✕

Please select from which backup to restore!

20210713_151218.db

20210713_101021_AutoBackup.db

20210521_143934_AutoBackup.db

20210521_090752_AutoBackup.db

20210521_085613_AutoBackup.db
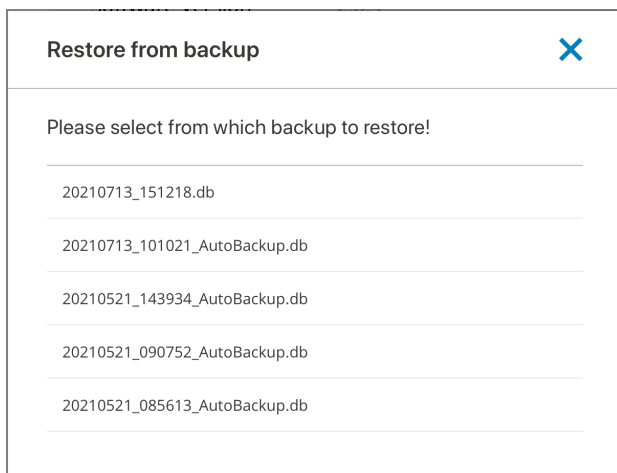
Abbildung 30: List of backup files

If you want to pull the data back to your tablet, the password will suffice. However, if you want to copy the data to another tablet, you will also need the identifier. STABILO does not know your password or identifier, so we will not be able to help you if you have lost either of them.

Caution: Restoring an old state from a backup **deletes the current data** in the app! If you want to keep the current state, perform a manual backup before restoring.

8.3 My Data

For the name and address in the reports to be correct, you must enter the name and address of your practice. This happens in this window; as usual, tap the line of the respective entry to let the virtual keyboard appear.

8.4 Legal Notices

In this section you will find
- A link to the imprint.
- A link to the terms of use.
- The STABILO GmbH privacy policy.
- Software licenses of all software libraries used in the app.
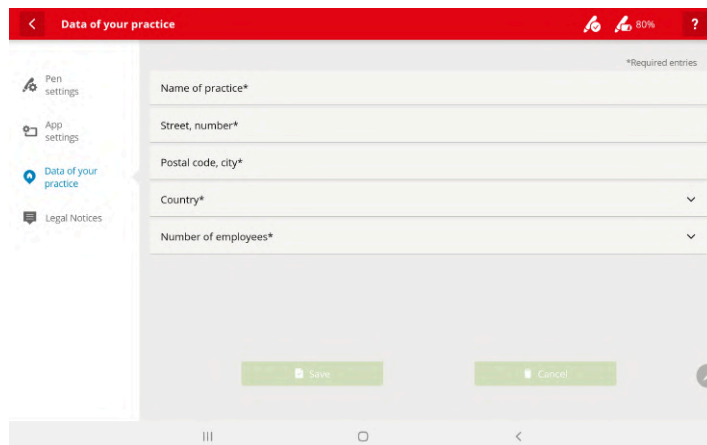
Figure 31: Data entry for your practice

9   Database for comparing measurements

9.1 Data collection

Each measured value is displayed relative to the measured values of a comparison group. These criteria must match to form a valid comparison group:

• Age

• Gender

• Handedness

Therefore, it is also necessary to specify these three parameters when adding a client entry (see section 5.3 on page 13). Only then is the correct selection of the reference data sets possible.

To generate the standard ranges for each individual parameter, approximately 1200 reference data sets from different age ranges were recorded. For each reference data set, the complete test was carried out with 9 test tasks and the parameters age, gender, education level and handedness were recorded[2]. At least 50 records were recorded for each of the following 20 age groups: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17-20, 21-30, 31-40, 41- 50, 51-60, 61-70, 71-75 and 76-80-year-olds. Attention was paid to an equal distribution between male and female subjects. The proportion of left-handed individuals corresponds approximately to the average of the general population.

9.2 Calculation of the standard ranges

From these results the limits of the standard ranges were determined for each age group by empirical quantiles:

- 0.25-quantile or lower quartile (the reading below 25% of the results)
- 0.5-quantile or median (the reading that divides the bottom 50% of the results from the top 50%)
- 0.75-quantile or upper quartile (the reading below 75% of the results)

The limits of the standard range were calculated separately for each of the above-mentioned age groups and for each result parameter. For example, for the parameter "degree of automation" there is a different standard range for 9-year-olds than for 15-year-olds. The handedness and gender play no role in determining the normal ranges.
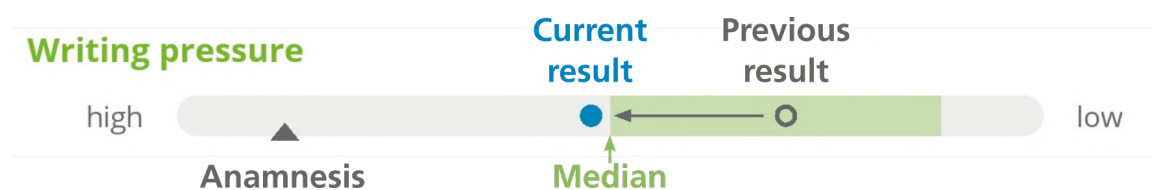
Figure 32: Excerpt from the results presentation from the ErgoPen Neo app with assignment of the statistical key figures using writing pressure as an example.

The graph in Figure 33 on the next page shows the limits, their definition and the reference to the standard range using the example of the writing frequency when writing the test sentence with 8-year-olds. The figures lower quartile (0.25-quantile), median (0.5-quantile) and upper quartile (0.75-quantile) show for the writing frequency that the slowest 25%, 50% and 75% of the scorers are below the respective limit. Specifically, this means that in order to reach the normal range for the writing frequency, the client's test result must be better than the results of 50% of the stored reference data. To get above the mean value of the standard range, the client's test result must be better than 75% of the stored reference data.

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[2] With the exception of the test sentence; this was only collected in the reference data once the subject was comfortably writing a full sentence.
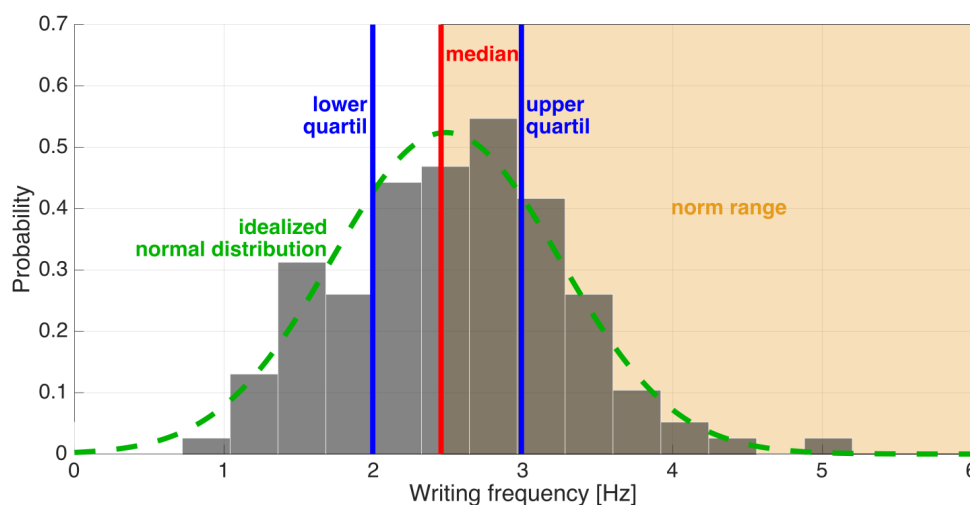
Figure 33: Distribution of the writing frequency in the test task "test sentence" for 8-year-olds. The normal distribution shown in green was calculated with the help of the mean value and the variance of the stored standard data.

For the parameter writing frequency, the goal is to achieve the highest possible value. The ranges are defined in the graph above. For the parameters duration, force and degree of automation, the goal is to achieve the lowest possible value and the normal range is defined below the median (in the direction of the lower quartile). For better clarity, however, the test results in the ErgoPen Neo App are plotted in such a way that the standard range can also be found on the right-hand side for these parameters. The aim of the writing angle is to achieve the most balanced angle possible. Therefore, for the writing angle, the normal range is defined as the range that is between the lower and upper quartiles. Table 2 on the following page gives an overview of the areas covered by the result bars. Please note that only at the right edge of the bar for the force and for the degree of automation a physical limit was chosen, which can not be undercut. All other result bar boundaries were chosen to give better resolution at the center of the bar, at the price of extreme values bunching at the upper and lower limit. For open-ended parameters, two standard deviations (σ) of the median were set as the left boundary, so that for normally distributed results, in test of 40 samples one will lie on the left edge of the bar.

The 0.25 or 0.75 quantile is not always in the middle of the normal range: Depending on the reference data of the age group, more than one quarter of the subjects can achieve a value of 1 for the degree of automation. Then, if the plot remained unchanged, the center of the normal range would fall on the right edge of the bar. Therefore, the right edge was set to the 0.25 quantile and the normal range is at least from NIV = 1 to NIV = 1.2. Thus, the lower range of possible results is better resolved than the upper range, which should be helpful in the practice of occupational therapy.

9.3 Assignment of the measurement results to the standard ranges

In the evaluation, the course of the quartiles and the median over age is smoothed out. This results in an analytic function of age for each parameter. The bases are the mean of the respective age group. Since the reference data only includes the age of the probands rounded to the nearest years or decades, the mean is the middle of the age group; the bases are thus: 5½, 6½, 7½, 8½, 9½, 10½, 11½, 12½, 13½, 14½, 15½, 16½, 19, 26, 36, 46, 56, 66, 73½ and 78½ years. Therefore, a client who is 8 years and 3 months old at the time of the test is compared to a reference value composed of the ¾-weighted value of the 8 year old probands and the ¼-weighted value of the 7 year old probands. This ensures that a suitable comparison value is calculated for each age. If one would compare the same client only with the 8-year-old probands, the reference group would be on average a quarter of a year older than the

Parameter	Left edge	Center	Mean of the normal range	Right edge
Duration	Median + 2σ	Median (0,5-Quantil)	0,25-Quantil	Median - $2\cdot$(Median - 0,25-quantile)
Force	Median + 2σ	Median (0,5-quantile)	0,25-quantile	0 N
Speed	Median - 2σ	Median (0,5-quantile)	0,75-quantile	Median + $2\cdot$(0,75-quantile - Median)
Frequency	Median - 2σ	Median (0,5-quantile)	0,75-quantile	Median + $2\cdot$(0,75-quantile - Median)
Degree of automation	Median + 2σ	Median (0,5-quantile), at least NIV = 1,2	Mitte zwischen 0,25- und 0,5-quantile	0,25-quantile (mostly NIV = 1,0)
Writing angle	Median - 2σ	Median (0,5-quantile)		Median + 2σ

Table 2: Limits of the bars in the result display

probands.

An inflexible assignment would be particularly disadvantageous at an age jump: A measurement shortly before the 9th birthday of the client would still be compared with the now half a year younger 8 year old probands, another shortly after the 9th birthday, however, would now be compared with 9 year old probands who already on average half a year older. An unexplained drop in performance relative to the now by one year older peer group would be the result. One consequence of this flexible calculation of the comparison values is that each new test is compared with a new reference value adapted to the current age of the test person. In a history plot plotting the numerical results of several measurements, the progression of the absolute quantiles would shift over the test period. However, if one only plots the relative position of the result to the quantiles valid at the respective test time, their course in the history plot remains constant over time.

In order to reproduce the relative as well as the absolute value of the measurement results in the detail overview, the measured value is added to the respective test date as a number in each history plot in addition to the point of the measurement. Therefore, when comparing the numerical measurements with the relative measurements in the history plot, it is important to keep in mind that the relative scale for the relative measurement results will shift over the test period. In extreme cases, this can lead to an improvement in the numerical values in the table over the test period, but to a decrease in the relative measured values in the history plot. However, this is easy to explain: In this case, the client's performance has objectively improved over the test period, but not enough to keep up with the simultaneous improvement of the reference data. In other words, in this case, the peer group has achieved a greater improvement in the readings over a similar period than the client.

10 Error messages and solutions to possible problems

10.1 Problems with the pen

Loss of Bluetooth-Connection

Since the ErgoPen Neo uses up a large part of the possible Bluetooth Low Energy connection bandwidth, several Bluetooth devices in the immediate vicinity may reduce the available bandwidth so much that the remaining bandwidth for the ErgoPen Neo is insufficient. Turn off unnecessary Bluetooth wireless technology enabled devices if your app is unexpectedly disconnected from the ErgoPen Neo.

Please note that devices that use the Bluetooth standard 2.0 will reach a higher transmission power than Bluetooth Low Energy and may therefore be particularly damaging for the bandwidth of Bluetooth Low Energy enabled devices.

Unstable Bluetooth-Connection

Sometimes it may help to reset the bonding information on both the pen and the tablet. For the ErgoPen Neo to reset bonding infromation, hold the on/off switch depressed after switching it on. You need to press the switch continuously for at least 12 seconds until you see a violet double blink which indictates that the bonding information has been reset.

How to reset the bonding information on your tablet is explained below in section .

Pen does not connect

If the pen does not connect, please check the following:
- When the pen flashes blue, it is ready to connect. If it flashes purple, please fully charge the ErgoPen Neo first.
- Is Bluetooth activated on the tablet? Please check this in an Android tablet under Settings - Connections - Bluetooth "On", in the iPad under Settings - Bluetooth "On".
- Has the location permission been granted? Only relevant for Android: Please check under Settings - Apps - ErgoPen Neo - Permissions - Location "On".
- If the pen still does not connect, turn off the pen and push the power button until it flashes purple. This takes approximately 10 seconds. In the app, press Connect pen. If a pop-up appears "Pair pen", press OK. Once the pen shows a continuously blue light, it is connected.

The calibration fails

The calibration requires sufficient coverage of possible directions during the calibration of the magnetic sensors. It will allow for up to 2500 measurements but if that still leaves too many directions uncovered, the calibration ends with an error. Please repeat the calibration and pay attention to the direction where the small rectangles light up. Try to move it into the dark areas of the rectangle in order to lighten up as much fo the rectangls as possible.

The LED flashes orange

A slow orange flashing of the LED during charging indicates a normal charging process. A quick single orange flashing during charging indicates too high internal temperatures. Please locate the pen in a cool and shady spot, let it cool down for a few minutes with the charger disconnected and then continue with

the charging. If, however, the LED shows a periodic orange double flash after the pen is switched on, the firmware has registered a hardware failure during the self-test of the electronics of the pen. Switch the pen off and on again. If the flashing still occurs after a restart, please contact STABILO support.

The LED flashes purple

A purple flashing LED during operation indicates a deeply discharged battery. The pen will shut down shortly thereafter and should be charged immediately. A purple flashing LED during charging indicates that the battery voltage is below the normal range. This is normal after a deep discharge and will change to a steady orange light when the voltage has risen sufficiently. A purple LED can also be observed when copying a new firmware and is completely normal.

LED at the bottom of the pen does not blink blue

If the LED light does not respond when the pen is switched on, please check whether the battery needs to be charged. If connecting the pen to a USB power source still does not switch on the LED, something in the electronics is probably damaged. Please send the pen in for repairs as described in section 10.1.

The time between two battery charges becomes noticeably shorter

The ErgoPen Neo contains a high-quality lithium-ion battery that can run for hundreds of charging cycles. If you find that its capacity decreases noticeably, STABILO can install a new battery for a processing fee. Due to the compact design of the pen, we advise against changing the battery yourself.

Caution: Danger of explosion due to improper battery replacement!
Disposal of used batteries according to instructions.

Please send the pen to STABILO to replace the battery.

The address for this is:

Schwan-STABILO Schwanhäußer GmbH & Co. KG
Industriestraße 47
91781 Weißenburg

10.2 Problems with the app

Pen was not found

If the search dialog box does not contain a single entry, no pen could be found. In this case, please check:

1. Is the pen turned on and blinking blue? If so, repeat the pen search. Not always a connection is possible immediately.
2. Is the pen close enough to the tablet? The range of the Bluetooth Low Energy connection of the ErgoPen Neo is only a few meters.
3. BLE on Android requires that apps be allowed to determine the location. Therefore, in Android devices, the location service must be switched on to ensure successful connection. You can do this via the app settings.
4. Sometimes it is necessary to cancel an already existing pairing with the tablet, so that the pen connects afresh with the app. Please follow the instructions in section 9 on the next page for Android devices.

5. If all else fails, try restarting the tablet. To do this, follow the instructions of your tablet for a reboot.

6. If this does not work, you can try resetting the tablet's network settings. Please follow the instructions in section 10.2 which deals specifically with Android devices.

7. If this does not work, check if the pen is supported by your tablet and whether other BLE devices can connect to it. The radio module in the ErgoPen Neo only supports the Bluetooth Low Energy (BLE) standard. In the settings of the tablet, check which Bluetooth wireless technology enabled devices it finds. If the pen does not appear in the list of BLE devices, make sure that your tablet actually supports BLE and that the BLE functionality is not broken. BLE support is indicated by terms such as "Bluetooth 4.0 or above" or as "Bluetooth smart" in the device description.

8. If the search yielded a result, the dialog fills up with entries of the MAC number and BLE names of the found BLE devices. Please tap on the entry that represents your ErgoPen Neo.

9. Android: Cancel pairing with the tablet

Sometimes it helps to cancel an existing pairing first in order to remedy connection problems. To do this, tap on the Settings icon in the Android home screen and then on the window that opens in the left column on the menu item Connections and on the right side on the entry Bluetooth. This displays the list of paired and visible Bluetooth devices (see Figure 34a). The linked ErgoPen Neo entry has a small sprocket symbol ⚙ (red arrow) in the line of this entry on the right, which you can tap on. This allows you to either rename or disconnect the pen.

(a) List of devices with Bluetooth connectivity   (b) Reset settings
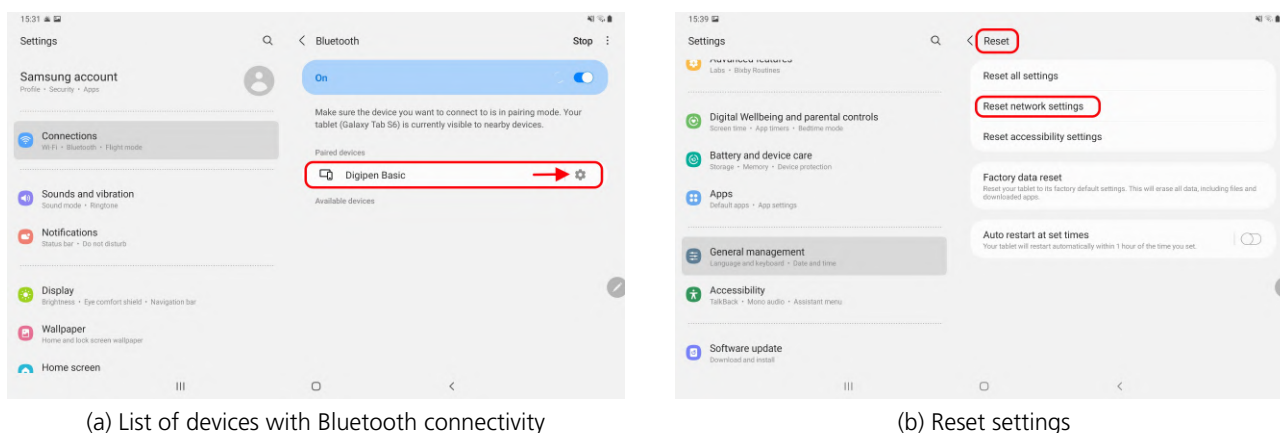
Figure 34: Modify Bluetooth settings in Android

Android: Reset network parameters

To do this, tap on the Settings icon in the Android home screen and in the window that opens, in the left-hand column, click on the menu item General management (near the bottom of the list) and on the right-hand side the entry Reset. This will display a selection of options for resetting several settings. The second (framed in red on the right in Figure 34b) concerns the network settings. Please note that after resetting, you will need to re-enter the password for Wi-Fi access.

Please avoid tapping on any of the other menu items! Resetting all settings means you will need to re-enter all the settings you have made so far, and if you reset the tablet to factory settings, all the apps you have installed before will also be deleted.

10.3 Questions?

If you have questions about the product or suggestions for the further development of the ErgoPen Neo, please write us an email to the address support.education@stabilo.com or call the service phone number 0049 - 911 - 567 1455.

11 General technical data

11.1 Pen

General operating temperature	0° C to 40° C
Battery charging temperature	5° C to 35° C
storage temperature (minutes)	-20° C to + 70° C
Storage temperature for longer periods	up to 1 month: -20° C to + 40° C more than 1 month: -20° C to + 35° C
Relative humidity during operation	20% up to 85%
Relative humidity during storage	10% up to 90%
Operating and storage location	Dust-free and dry environment, closed spaces
Size (L × D)	167 × 15.0 mm (including cap)
Mass	about 25 g
Radio protocol	Bluetooth® Low Energy 5
Frequency bands	2.402 GHz to 2.480 GHz in 20 MHz raster
Maximum transmission power	1mW / 0dBm
Battery type	Lithium Ion Battery
Charging time (typical)	3 hours
Charging time (maximum)	4 hours
Maximum charge current at USB cable	1 Ampère
Continuous operation time (typical)	15 hours
Force measurement	4096 steps
Tilt range	any

11.2 Tablet for ErgoPenNeo-App

Screen size (diagonal)	Android: 9,7 inches oder more
	Apple iOS: 7, 10 or 13 inches
Operating system	Android 8.1 (Oreo), API-Level 33 or newer
	Apple iOS 13 or newer
Internal memory	16 GB or more.
Processor clock frequency	1.6 GHz or higher
Bluetooth®-Support	Bluetooth® Low Energy (BLE), Bluetooth® 4 or newer.

12   Important information about this product

12.1 Instructions for Use

The STABILO ErgoPen Neo (hereafter referred to as the "product") supports you in your daily work by making graphomotorics easy and efficient to measure.

Warnings

- The product must not be used near an open flame or outside of the specified temperature range (see "General Specifications").
- Avoid damaging the cable. Do not place heavy objects on the cable, do not kink it repeatedly, and do not apply strong pressure to the cable connections. Torn or otherwise damaged cables can increase the risk of product failure, electric shock or fire hazard. Stop using the product if it is damaged.
- The product must not come into contact with water or other liquids.
- Do not insert foreign objects into the USB port or other openings of the product, except the opening for the switch to reset the product.
- Failure to follow these instructions may result in the product not working properly, being irrevocably destroyed, or presenting a risk of electric shock.
- Do not use organic solvents (eg alcohol) or detergents to clean the pen. The use of such solvents or cleaning agents can damage the product. Such damages are not covered by the warranty.
- Do not use the product in storms or thunderstorms. When it is being charged in such weather, stop charging. Overvoltage due to lightning may cause product failure, fire or electric shock
- Operation of the product outside the specification (see "General technical data") is not permitted.
- At the end of its life, please recycle the product in accordance with the manufacturer's recommendations and in compliance with all local laws and regulations.

Instructions for use

- Do not drop this product or beat it on another object. This can damage the product.
- To avoid malfunction, keep this product away from magnets and magnetic fields.
- To avoid possible damage or malfunction, do not apply excessive pressure to the pen tip of this product. This could shorten the life of the pen tip or cause malfunction.
- Only use STABILO refills which are specially developed for this pen
- Do not disassemble or modify the product, as this may cause irreparable damage.
- Charging the product: Use only the included USB cable and charger to charge the product.
- The USB cable and charger may become warm during normal operation. This is normal.
- Disconnect the USB cable and charger from the mains if one or more of the following conditions are true:
    - The cable is worn or damaged.
    - The charger is exposed to rain, liquid or extreme humidity.
    - Charger or cable must be cleaned.

SVHC materials

Regulation (EC) No 1907/2006 (REACH), Article 57, requires information on material of very high concern. The ballpoint pen tip of the ErgoPen Neo contains more than 0.1% lead in its metal alloy, which was added to the list of substances of very high concern (SVHC list) on June 27, 2018. According to the tip manufacturer, the lead content is between 2% and 3%. The tip is mainly made of nickel silver, an alloy of nickel and copper, to which lead is added in order to be able to machine the material. There are currently no lead-free nickel silver tips on the market; we will replace the tip in the ErgoPen Neo as soon as technically possible.

Lithium Battery Test Summary in Accordance with Subsection 38.3 of the UN Manual of Tests and Criteria

Name of battery manufacturer: Shenzhen TCBest Battery Industry Co., Ltd.

Battery manufacturer contact information: 5/F, Building A6, Yintian Industrial Zone
Xixiang, Bao'an District, Shenzhen, 518000, China

Name of test laboratory: Shenzhen NCT Testing Technology Co., Ltd.
1B/F, Building 1, Yibaolai Industrial Park, Qiaotou, Fuyong
Bao'an District, Shenzhen, Guangdong, China
Tel.: 0086 755-27673339
URL: http://www.nct-testing.cn

Test Report: ID TCT201228B199

Date of Test Report: Dec. 30, 2020

Description of battery:
a: Type: Lithium-polymer battery
b: Mass: 10 g
c: Watt-hour rating: 1.3 Wh
d: Physical description: Cylindrical, 10 mm diameter, 44 mm long.
e: Model number: 10440

List of tests conducted, results:
a: Altitude simulation according to UN38.3 Test T.1, 10 specimens: Pass
b: Thermal test according to UN38.3 Test T.2, 10 specimens: Pass
c: Vibration according to UN38.3 Test T.3, 10 specimens: Pass
d: Shock according to UN38.3 Test T.4, 10 specimens: Pass
e: External short circuit according to UN38.3 Test T.5, 10 specimens: Pass
f: Impact according to UN38.3 Test T.6, 10 specimens: Pass
g: Forced discharge according to UN38.3 Test T.8, 10 specimens each: Pass

Testing requirements: UN manual of tests and criteria, subsection 38.3 (UN 38.3)

Edition/Amendments: ST/SG/AC. 10/11 Rev. 7 Section 38.3

12.2 Legal information

EU conformity information

The product complies with the requirements of the European regulations for electrical safety according to ISO 60950, the electromagnetic compatibility according to EN 301 486, 55024 and 55032, the photobiological compatibility according to EN 62471 as well as the RoHS regulation. For details, please see: www.STABILO.eu/certificates

Directive on Waste Electrical and Electronic Equipment (WEEE)

This symbol requires within the European Union that this product may not be disposed of with the trash. It should be returned to an appropriate facility for recycling. Please follow the guidelines of your country for the responsible recycling of this product.

Compliance with environmental standards

EU information on battery disposal

Note: This symbol is only valid for EU countries. This symbol is used in accordance with Directive 2006/66 / EC Article 20, information for final consumers, Annex II. This product was developed and manufactured using high quality materials and components that can be recycled and / or reused. This symbol indicates that batteries and accumulators may not be disposed of with household waste after their life cycle. There are different collection systems for used batteries and rechargeable batteries in the European Union. Please dispose of batteries and rechargeable batteries according to regulations at your local collection / recycling point. Please support us in preserving our environment!

For your own safety, do not attempt to remove the battery. Failure to properly remove the battery may result in damage to the battery and the device, personal injury, and / or unsafe equipment. If the battery needs replacing, contact the manufacturer.

12.3 Voluntary Guarantee / Assurance

STABILO warrants / assures you as the first purchaser (hereinafter referred to as "you" or "customer"), that the product hardware will be when used according to specification (see "General Technical specifications") for a period of two years, from the date of sale, free from defects in materials and workmanship, at the condition that they were unused at the time of purchase. Any defects in materials or workmanship occurring during this period will be repaired or the product replaced at STABILO's discretion. Defects in wearing parts (e.g. pen tips or battery) that are due to normal usage and operation, as well as defects caused by the customer's own fault, such as drops or improper handling, are excluded from this warranty. If a defect is found in the product or for the professional replacement of the battery, please return it to the original place of purchase in the original packaging together with your name, address, telephone number, a description of the defect and a copy of the original invoice. The customer is liable for any loss or damage to the product during this transport. If you have any questions about this agreement or wish to contact STABILO for any other reason, please contact us in written form. Legal claims concerning the warranty remain unaffected.

You additionally have the option to purchase a STABILO warranty extension, Digital Pen Care, on our website. With Digital Pen Care, you can extend the warranty of your ErgoPen Neo for a further two years for a one-time fee.

12.4 Declaration of conformity

Hereby STABILO International GmbH declares that the radio equipment type ErgoPen Neo complies with guideline 2014/53 / EU. The full text of the EU/UKCA Declaration of Conformity is available at the following Internet address: EU/UKCA Conformity Declaration.