SYNAPTIVE

The Human Hair Atlas

Hair, EEG, and where the Syn-R1 electrode works.

Syn-R1
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synaptiveltd.co.uk

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Where we stand

We've spoken to a lot of people about this, and run the experiments ourselves, as a team and academically, and the same point keeps coming back: given enough time, someone can get a signal out of any hair.

We don't disagree with that. What we've seen first hand is that most people don't think the value is worth it, and the lack of participants from diverse backgrounds is the evidence. New techniques, longer setups, more training, none of it pays them back.

So we decided to build the hardware instead. It isn't that signals are impossible today, it's that the devices aren't the right tool for the job, and people won't spend time learning more than they have to. Hardware is the easier thing to adopt, because you buy it and it works and you've learnt nothing new on your end, which is more than we can say for standing here preaching, or running workshops on why we should all do better, with no clear path or offering at the end of it.

Syn-R1 is part of that, and so is this atlas, but it's more than both. It's years of understanding that equity and doing the right thing don't move habits. Value does, and that's what we're trying to provide.

What EEG is

Electroencephalography (EEG) is a brain recording method which measures the electrical activity of your brain, completely non-invasively. The signals are tiny, a few millionths of a volt, which is why placing the electrodes as close to the scalp as possible is so important.

In an EEG session the participant wears a cap, sometimes stretchy plastic, sometimes silicone, sometimes mesh. The caps have holes at standard positions, the 10-20 system, named from the percentages used to space them across the head. The technician puts an electrode in each hole, parts or clears the hair under it, and adds a conductive gel so current can pass between skin and metal. Then they check impedance, a measure of how hard it is for that current to flow. Most labs want it under about 10 kΩ before they start. This is the part researchers say gives them the most difficulty with different hair types.

Once everything is below that, recording runs for anywhere from twenty minutes to a few hours, depending on the study or the clinical question. Afterwards the gel washes out and the participant goes home.

Why contact decides the recording

An electrode that is not connected properly still shows up as something. To a trained eye it is just more noise: slow drift, mains interference, and more movement artefact. Most of it is difficult to reduce after acquisition, which means if a channel did not make good contact, the options are limited later for what you can do.

This is why we think hair matters, and it is not because any hair is more difficult. Hair is just different. New resources on recording EEG in different hair keep appearing, and they ask researchers to change how they work. Habits do not shift that easily, so we think the gap is in the hardware. In practice it blends together: some styles cannot work at all with what exists, others can with time and training that researchers do not get. Hair sits between the electrode and the skin, and getting past it is the job of placement.

Why hair matters

Most EEG hardware was designed around straight and wavy hair. On curly, coily and textured hair, electrodes sit on the hair rather than the scalp, impedance climbs and data quality drops.[8]

Researchers just drop participants with different hair types.[5,13,23] We have seen it written into the exclusion criteria of studies that passed ethics review. Black participants are under-represented in EEG research,[2,4,6] and in clinics the same problem has put people off tests they needed.[16]

This guide is a start on what we have learnt at Synaptive: how different hair sits on the head, where Syn-R1 reaches the scalp, and where it does not.

We have three labels.

● Works so far	We have used it on this and it reached the scalp. Not yet measured across enough people to call it proven
● Should work	Same mechanism, but we have not done it often enough to say
○ Not yet	No electrode does this today, ours included. It needs a solution

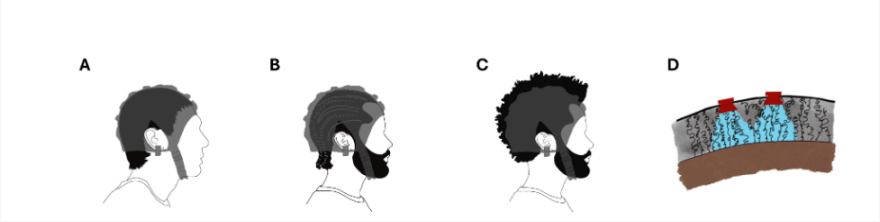

Figure 1. A, short hair. B, cornrows. C, voluminous natural hair. D, coils reaching the scalp through coily hair, with gel at the tip only.

The hair itself

Hair is classified from 1 to 4: straight, wavy, curly, coily, each split a, b and c. It is a useful shorthand, and worth recording, but on its own it does not tell you how a session will go.

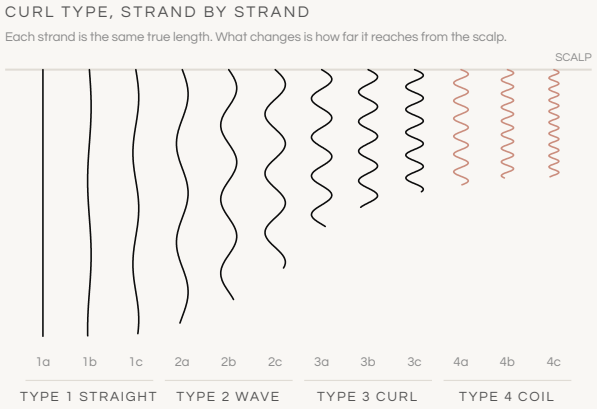

Figure 2. Curl types 1a to 4c. Every strand is the same true length.

Two things decide that:

- How much hair sits between the cap and the scalp. Curl, length and volume together. A shrunk afro and a braided head can be the same hair and behave nothing alike.
- Whether the hair is loose or bound. Loose hair threads easily, but bound hair gives the coil three ways in: through the braid itself, through the pulled strands at the root which stay penetrable even on a style done that day, or in the gap between units. With hair bonded to a weave though, there is no way in so far.

> Record the type, the density and the length as worn, along with anything on the hair that day. Oil, butter and edge control all raise impedance, whatever electrode you use.[14]

How Syn-R1 works

A cap holder, a PEEK tube turned into a coil, and a sintered Ag/AgCl pellet at the tip.

Twisting does all the work. The coil threads down like a corkscrew, lifting and parting strands around the site rather than pressing hair flat, and keeps going until the tip meets the scalp. Don't need to part by hand.

- In short hair the cap holds the pellet down, the same as any other electrode.
- In longer hair the coil is what gets you there, and the gel makes the connection at the tip.

The one limit

The tip is about 25 mm long. Compressed hair under the cap has to fit inside that.

$$\text{hair under the cap} \leq 25\ \text{mm}$$

Loose afros up to about 60 mm tall compress enough to be within it. Deeper than that and the tip runs out, whatever the curl pattern. A longer tip is the only way past it, and that is on our list.

Place, twist, gel

There are three steps to get the electrode to work.

Figure 3. The three steps at a site.

Before you start

1. Fit the cap as you normally would with the coil as high up as possible, not screwed down. Check the midline sits where you expect.
2. Clean each site with soap or alcohol if you want. It is not always common in research EEG but it helps a lot. Product on the scalp raises impedance.
3. Have the gel syringe ready before placing. It has to be a blunt nose needle syringe, the kind with a flat-ended metal tip long enough to run down the tube, because a sharp hypodermic or a plain nozzle syringe won't get the gel down to the pellet and our electrodes may not work with them.

Placing

1. **Place.** Seat the electrode in the cap holder at the site.
2. **Twist.** Turn the electrode and let the coil thread down through the hair. Two or three turns is normal, more in long or dense hair. You'll feel the tip stop and see the cap raise, but when in doubt just ask the participant if they feel the pellet.
3. **Gel.** Once the tip is down, put the blunt nose syringe into the top port and run it as far down as it goes, so the gel lands where the pellet already is.

You want a thin layer between pellet and scalp, nothing more but gel as you require.

4. Check impedances before moving on. Under 20 kΩ is the usual target in research, and sub 10 kΩ in medical use.

If a site will not settle

What you see	What to do
No stop after several turns	Keep turning rather than pressing. In bound hair, aim at the strands pulled towards the root, or the gap between units
Still no contact	The hair is deeper than the tip can reach. Move to the nearest parting, or offset the site and note it
Impedance high after gel	Add a little more gel, or lift and re-seat. If it stays high, clean the site again: product is the usual cause
Channel noisy or drifting	Check the tip is still on its site. Tall hair can push a coil sideways after placement
Participant reports pressure	Back the twist off a turn. The spring only needs enough force to hold contact

Removing and cleaning

1. Twist the other way to remove, so strands unwind instead of pulling.
2. Because the gel sits at the tip rather than spread through the hair, there is far less to wash out. That is time saved at the end of the session, gel saved per participant, and less cleaning between them. A straw cleaning brush is ideal for getting through the tube.
3. Clean the electrodes as you would any wet Ag/AgCl electrode, and let them dry before storage.

Log it

Per site: hair type, style, whether the tip reached the scalp, how many turns, time to signal and impedance at ten minutes. Those logs are how this guide improves, and the last section says how to send them to us.

Styles

Style matters more than curl type. This is what we've seen so far.

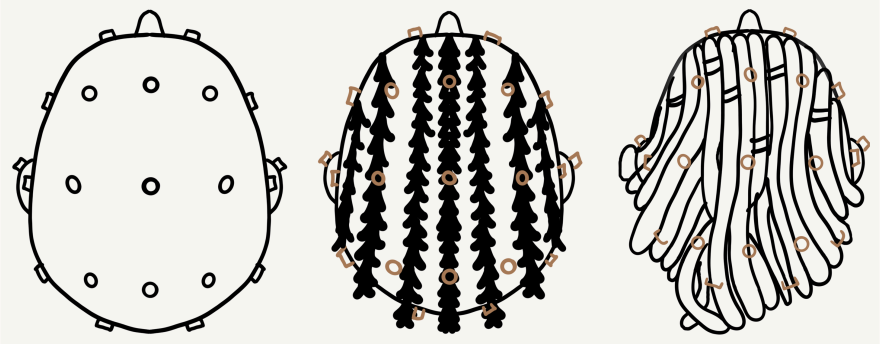

Figure 4. Short hair, cornrows and locs, with the cap sites marked.

Short hair: shaved, buzz, fade, TWA

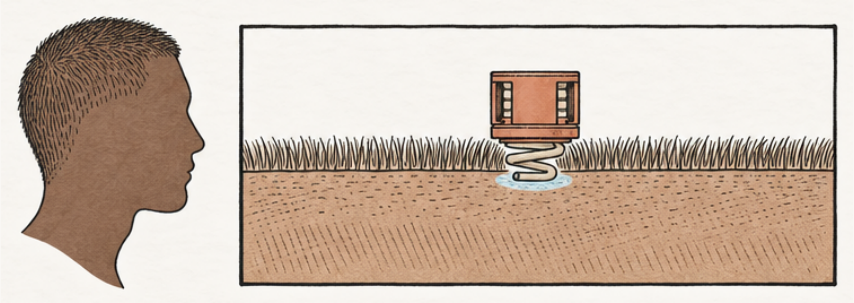

Figure 5. Short hair.

Almost nothing between cap and scalp.

The cap compresses what's there and holds the pellet down, so you won't need many turns, just watch for gel on stubble at the mastoid reference.

- Works so far

Loose natural hair and afros

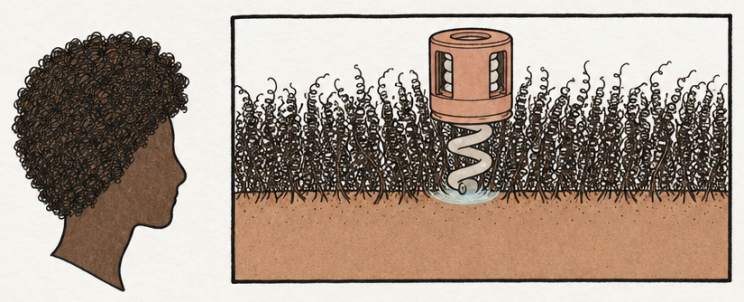

Figure 6. Loose natural hair.

Deep and springy, and the whole cap sits higher because of it.

The coil threads down and the gel connects at the tip, so afros up to about 60 mm tall reach the scalp and past that the tip runs out. Tall hair can push a coil off its site too, so check the tip is still where you put it.

- Works so far

Long coily hair tied up: puffs, pineapples, high buns

Open where it's pulled flat, closed under the bundle.

Long type 3 and 4 hair does two different things on the same head, because where it's pulled towards the tie the strands are stretched flat and thinner than when they're loose, so the coil goes in at the root much like it does on cornrows, but under the bundle itself there's no way in, and the bundle lifts the cap around it too, not just the site underneath.

Ask for it low at the nape before the cap goes on, or in two low puffs, because a puff on top costs you Cz and whatever's next to it. If it has to stay up, take the ring of sites around it and write down the ones you couldn't.

- Should work

Long straight or wavy hair

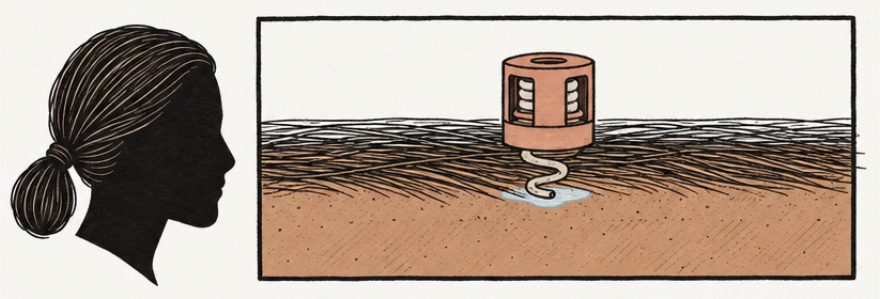

Figure 7. Long hair, tied low.

Not deep, but a lot of it.

Standard placement, just tie it low because a bun or ponytail under the cap lifts the occipital sites.

- Works so far

Cornrows, flat twists and feed-in braids

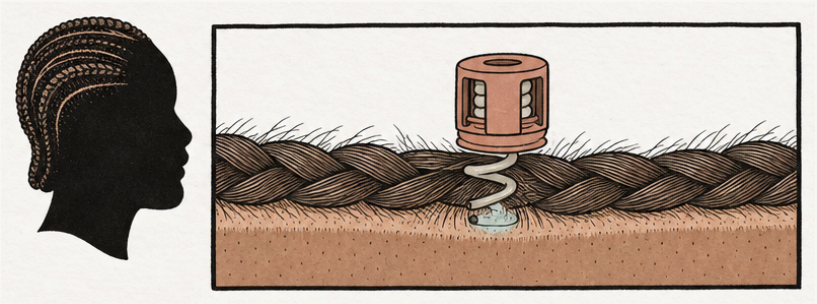

Figure 8. Cornrows.

Rows of hair with bare scalp between them.

It's case by case, and there's more than one route in, because the coil can go through the small braids, between them, or through the pulled strands at the root. Start on the site, and if it stalls move to the nearest part and note the offset, but don't assume every braided head behaves the same.

- Works so far

Box braids and twists with extensions

Square parts, with added hair and added bulk.

Same routes in as locs, so small braids take the twist directly, and on thicker ones you go in at the strands pulled towards the root or use the grid of parts. What the coil won't do is thread into a thick braid itself so don't force it, and bear in mind extensions lift the cap at every site, not only the braided ones.

- Should work

Locs, two-strand twists and Bantu knots

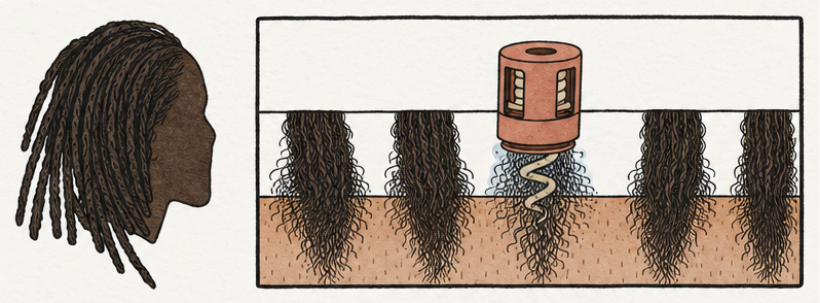

Figure 9. Locs: in at the root, not into the loc.

Hair bound into units, with scalp visible only between them.

There's usually a way in, because the strands pulled towards the root stay penetrable even on locs that were just retwisted, and the gap between units is there as well. What the coil won't do is thread into the solid body of a loc, so don't force it, and ask before spreading locs apart or moving a knot off a site you need. Locs also add weight, which lifts the cap.

- Should work

Silk press and relaxed hair

Straightened, and easily undone.

Mechanically this is the easy case, the problem is the gel, because moisture will revert a silk press and ruin a style someone paid for. Until we have an answer, say so at booking rather than on the day.

○ Not yet

Wigs, weaves and extensions

Added hair, either removable or bonded.

A wig, clip-ins or a wrap come off and what's underneath is usually cornrows, so follow that entry. A sew-in, closure or glued front can't be removed on the day, so only leave-out areas are reachable and often there are none, and nothing on the market reaches through bonded hair.

● Works so far after removal. ○ Not yet for bonded hair.

Faith, identity and head coverings

EEG device development, ours included, leaves out people whose faith or identity shapes how they wear their hair. Work on hair equity has focused on texture.[1,5,13] Head coverings barely figure in electrode or cap design.

No electrode or cap we know of can record through a covering. The only option today is removal, and for many people that is not something they will agree to. Those participants are currently excluded rather than accommodated, and pretending otherwise helps nobody.

Neither of these has a solution today, ours included.

What to do

1. Ask at booking, not on the day. The form asks whether anything about their hair or head covering needs planning for.
2. Never guess someone's faith from how they look.
3. Offer a private room and a technician of their chosen gender before they have to ask, and allow time to re-cover.
4. Declining to remove or change anything costs them nothing: no exclusion, no lost payment, no second ask.
5. If they do agree, plan the montage around what stays on and record every site lost.

Worn	What may matter
Hijab, sometimes with an underscarf	Uncovering in front of unrelated men
Dastar or turban, patka, with the joora at the crown	Removing the turban. Hair must not be cut. The joora blocks the crown
Tichel or sheitel	A sheitel is a covering, not an ordinary wig
Locs worn for faith	Not combed or separated, by anyone
Uncut long hair in some Christian traditions	Cutting, and sometimes uncovering
Shaved head with a tuft (shikha)	Disturbing the tuft

Cost and identity work the same way. Someone who has paid for braids, or who wears locs as part of who they are, is not obliged to undo them for a recording.[5,14]

Before the session

These apply whichever electrode you use, and follow Inclusive Neuro[14] and published recommendations.[5,7,13]

1. Ask about the style when you book. Wigs, sew-ins and fresh braids change the plan, and a two-line question saves a failed session.
2. Ask people to arrive detangled, stretched overnight if they can, with no fresh oil or edge control on the scalp. Book on or just before wash day.
3. Never ask someone to change or remove a style without saying why, offering an alternative and, in research, paying for the time. Mistrust of research in Black and Brown communities is documented and justified.[2,5,16]
4. Decide your offset rule in advance. A clinic can move a site and note it. A research lab has to apply one rule to everyone.
5. Plan aftercare: a wash station, shampoo, conditioner, a mirror and time. Let people bring their own products.

What we haven't solved

No order, no ranking. These are open.

Problem	Who it affects
Reaching hair deeper than 25 mm when compressed	Long Type 4, full afros, high-tops
Tall hair pushing the coil off its site	High-tops, voluminous hair
Cap lift from volume, extensions or locs	Afros, braids, locs
Gel that will not revert a straightened style	Silk press, relaxed
Reaching the scalp under bonded hair	Sew-ins, closures, glued fronts
Recording with a head covering in place	Hijab, turban, tichel

We also check each of these for harm: strands lost, and how disturbed the hair felt after removal.

Help us close them

If you use Syn-R1 on hair marked Should work or Not yet, your session is how that changes. Send it to us and we will help with the protocol, troubleshoot on the day, and credit you in the next edition.

Per site, with participant consent under your own ethics approval, and nothing identifiable:

- Curl type, density, and length as worn
- Style, and whether anything could not be altered
- Whether the tip reached the scalp, and how many turns
- Time to signal, and impedance at 10 minutes
- Comfort, and any hair disturbance on removal

> admin@synaptiveltd.co.uk
> synaptiveltd.co.uk/evidence

References

1. Kwasa et al. (2024). Untangling bias. *Science*. doi:10.1126/science.ads7375
2. Webb et al. (2022). Addressing racial and phenotypic bias in human neuroscience methods. *Nature Neuroscience*. doi:10.1038/s41593-022-01046-0
3. Adams et al. (2024). Fostering inclusion in EEG measures of child development. *npj Science of Learning*. doi:10.1038/s41539-024-00240-y
4. Manfredi et al. (2023). Racial bias through EEG. *BMC Psychology*. doi:10.1186/s40359-023-01125-2
5. Choy, Baker & Stavropoulos (2022). Systemic racism in EEG research. *Affective Science*. doi:10.1007/s42761-021-00050-0
6. Penner et al. (2023). Racial disparities in EEG research and the maternal brain. *Cognitive, Affective, & Behavioral Neuroscience*. doi:10.3758/s13415-022-01040-w
7. Brown et al. (2023). Conducting EEG research with Black individuals. doi:10.1177/23727322231197739
8. Lees et al. (2023). The effect of hair type and texture on EEG and ERP data quality. *Psychophysiology*. doi:10.1111/psyp.14499
9. Bradford et al. (2022). Whose signals are being amplified? *Clinical Psychological Science*. doi:10.1177/21677026221112117
10. Kier et al. (2025). Think about us. doi:10.1080/24711616.2025.2600346
11. Novel electrodes for coarse and curly hair (2024). PubMed 40039628
12. Etienne et al. (2020). Novel electrodes for reliable EEG recordings on coarse and curly hair. *IEEE EMBC*.
13. Louis et al. (2022). Hair me out. *Frontiers in Human Neuroscience*. PMC9774030
14. Inclusive Neuro. For clinicians and researchers. inclusiveneuro.com
15. Inclusive Neuroscience Handbook. inclusiveneuro.com
16. KFF Health News. How one patient's textured hair nearly kept her from a needed EEG.
17. BioSemi user forum (2020 to 2023). Thread on hair and electrode contact.
18. Carnegie Mellon University (2019). Students explore EEG.
19. Brain Products. Inclusivity in EEG research.
20. Black in Neuro podcast.
21. Hello Brain Lab, UCF. EEG hair project.
22. Precision Neuroscopics. Sevo electrodes.
23. Kelly, Patel, Bryan, Kier & Carlson (2026). Diversity in BCI: why it matters. *Graz BCI Conference*.