Swipe to Unlock

How the Materiality of the Touchscreen Frames Media Use and Corresponding Perceptions of Media Content

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Abstract

Since the release of iconic devices like the Nintendo DS *(2004) and particularly the first* iPhone *(2007), touchscreen interfaces have become almost omnipresent and arguably shaped a "touchscreen generation". But how do touchscreen experiences operate as complex assemblages of material contingencies, electronics, algorithms and user interaction? And how do they function in actual software applications? In order to address these questions, the paper outlines a comparative software studies perspective, which comprises four consecutive steps. The introduction draws on cultural studies research on touchscreen interfaces to establish a theoretical framework for understanding the shifting epistemic status of the screen and the complex relationship between technical affordances and cognitive processes. Second, the paper explores aesthetic implications of the materiality of touchscreens, including the shift from vertical to horizontal navigational logic and the focus on physical contiguity in user experience design. Third, a series of short, interconnected case studies serves to illustrate the more specific implications on practices of media use and cultural production in a variety of applications. For example, apps like* Vine *evoke the 'tangibility' of digital material by allowing users to start and stop recording video by touching and releasing the screen respectively. Other, even more iconic examples include the swipe mechanic employed in* Tinder *and particularly the 'swipe to unlock' gesture used in the* Android *operating system. Finally, the previous findings are contextualised by briefly investigating the cultural imaginary of the touchscreen, which manifests itself in the form of haptic feedback as well as curved and even wearable touch-sensitive surfaces.*

Introduction: Touchscreens between hardware and software

Since the release of the *Nintendo DS* (2004) and especially the first-generation *iPhone* (2007), touchscreen interfaces have become almost omnipresent (cf. e.g. Verhoeff and Cooley 2014), to the point that their influence especially on younger media users has been conceptualised using terms like the "touch screen generation" (Wohlsen 2014; Rosin 2013). This ascription implies that

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users for whom touch-based devices are the primary reference medium share some common perceptions and practices based on the assumption that display and interface converge. In the aforementioned article, Hanna Rosin hints at the epistemic implications of touchscreens, stating that children's television formats like *Dora the Explorer* might actually be understood as "precursors" to touchscreen technologies in that they prompt young viewers to respond, include pauses for them to do so and 'respond' to the anticipated answer of the child. While existing research on touch interfaces usually focuses on the devices themselves, this paper undertakes a 'close reading' of several iconic gestures used across different software applications to address this epistemic shift and to demonstrate how these increasingly naturalised gestures shape our perception of media content.

Nanna Verhoeff approaches the topic primarily in terms of the navigational practices touchscreens afford. For instance, she describes the touchscreen as a "thin, but essential and visible membrane" that "flattens the surface" of the device it is part of (Verhoeff 2012: 65) and as a "map" that simultaneously constitutes and re-presents "screenspace" (ibid.). Furthermore, Verhoeff points out that touchscreens increase the awareness of the long-standing notion of "moving through" the screen, which thereby is intuitively understood as a "window" (ibid.: 82).

Put differently, the touchscreen effectively operates as an evocative object, i.e. as a thing "we think with" (Turkle 2007: 5), since its use affects several basic cognitive practices. For instance, educational scholars point out the cognitive connection between fine motor skills and young children's "early comprehension of the world" (Grissmer et al. 2010: 1008). Studies like this propose that fine motor skills at preschool age can be a predictor for later achievements in mathematics, reading or the sciences. In this context, touch-based interaction is certainly a factor worth taking into account; however, qualitative suggestions on that assumed connection are still lacking. Another analytical vantage point might be Arnold Pacey's notion of "meaning in the hands" (Pacey 2001: 59), which refers to the fact that many (scientific) ideas originated in visual impressions that suggest a certain tangibility[1] and triggered the process, which led to the subsequent formalisation of the problem. Other scientifically relevant ideas 'occurred to' their originators while being idle but also, characteristically, while "walking, riding, or traveling" (ibid.: 60). This Aristotelic notion of peripatetic reasoning resonates with the touchscreen affording practices of navigating/traversing the screen (in the sense of Verhoeff), i.e. emulates casual physical activity within a digital medium. On top of that, touchscreens enhance this cognitive process because, as screens, they combine the navigational gestures with contingent images and visual semantics.

As Paterson (2007) points out, touch is essential to "embodied experience" (ibid.: 1) itself, a complex sensory modality that not only provides information

1 Pacey mentions e.g. Kekulé and the concept of the benzene ring, which was arguably derived from a mental image of molecules "twining and twisting like snakes" (ibid.: 60), a description that strongly invokes the sense of touch.

about the outside world but also performs communicative functions, creating "an empathetic or affective bond" (ibid.: 3). This connection between touch and bodily self-awareness has been and is being used by a number of recent technologies to reinforce the "sense of immersion in an artificial environment" (ibid.: 133). However, touch-based interfaces thereby also add a distinct performative quality (Macaulay et al. 2006) to Human-Computer Interaction (HCI) and in particular to contemporary relationships towards consumer technologies. While the materiality of pressing a button encompasses a number of factors such as the surface material or the intensity of the push, from a software perspective it is reduced to a binary distinction (on/off). Already via a computer mouse, users could make more idiosyncratic movements (e.g. following the point on the screen currently looked at with the mouse without actually clicking). This has been mostly studied from an ergonomics perspective (Wahlström and Svensson 2000) but the differentiation according to gender and work methods already hints at subtly subjectified forms of use. In comparison, though, touchscreens afford even more personalised form of interacting with digital devices, some of which will be illustrated in the case studies below. For the purpose of this paper, though, the most important aspect is the fact that for media users growing up with touch-based devices the epistemic status of a screen is fundamentally different from that of users for whom television or the cinema have been the primary reference points (cf. Schybergson 2014), i.e. for them screens "always hold the promise of interactivity" (ibid.). For that reason, they exert an almost physical attraction and the hapticity of touch-based interfaces often becomes the entry point into digital technologies and 'algorithmic literacy'.

While the aforementioned concepts help understanding the touchscreen and its implications for the use and interpretation of media content, this paper encourages a closer look that demonstrates how the material experience is dependent on a combination of hardware and software. The first part will focus on how touch input is re-presented on the software level, e.g. in terms of user interface (UI) conventions. It draws mainly on the *Google Material Design Language* (GMDL) as a central case study. The second part expounds the three most basic types of touch gestures (tapping, holding and swiping), the ways in which they are implemented and remixed across different applications as well as the cultural implications of their daily, millionfold use. This second line of argumentation is essentially comparative; it proposes a finite set of generalisable patterns and draws on a broader corpus of mobile applications[2] as well as the two main mobile operating systems iOS and *Android* to illustrate how these patterns play out in different contexts.

2 The case studies include applications that are prominent in mainstream media discourse like *Tinder* but also more quirky, ideiosyncratic apps like *Swapp*, which are important for a comprehensive perspective because they play with and explore touch gestures in ways that bigger commercial products are not willing or able to.

Aesthetic implications of touchscreen technologies

An important step in assessing the materiality of the touchscreen will be to investigate its relationship to media aesthetics, i.e. to establish a connection between hardware and software, most importantly on the level of user experience design. For instance, drawing on the material constraints of touchscreens, many applications more or less arbitrarily divide the screen into 'regions' (which may or may not correspond to visual borders) to avoid ambiguous input. For instance, the tablet version of the popular multimedia player *VLC Media Player*[3] distinguishes between sliding gestures in the top, bottom, left and right of the screen to control aspects like volume or brightness. Second, horizontal swiping gradually replaces vertical scrolling as the dominant navigational logic. Verhoeff (2012) already points to the epistemic difference between mouse-based scrolling and the notion of "panning" (ibid.: 84) in the version of the *Opera* web browser on the *Nintendo DS* game console, which still resorts to the scrolling paradigm but makes it more 'immediate' through vertical swiping, albeit being designed for use with a stylus rather than a finger. One high-profile application that institutionalised the horizontal organization of content is *Paper*, an alternative and distinctly mobile entry point into *Facebook*'s core functionality. Leveraging the metaphor of the newspaper to organise *Facebook* content, the app uses the lower half of the screen to cycle horizontally through available stories. Paper pairs the essential horizontal navigation with a double upward swipe to 'open up' a story, a gesture that – through its material quality – is described as "oddly satisfying, like picking up a newspaper, then bringing it closer to your face for reading"[4].

An even more prominent example of horizontal navigation that illustrates two more important characteristic is *Tinder*, an online dating app that has become part of mainstream media culture through its iconic use of left and right swipes to either reject or approve of a user profile. *Tinder* demonstrates the influence of touch input in that the swipe has even been picked up on in colloquial language use, where 'swipe right' has become a consensual expression for accepting something[5]. Furthermore, the *Tinder* mechanics hint at two important aspects of touch control, the intrinsically playful quality (that could be described with Roger Caillois in terms of 'paidia' and 'vertigo') and the potential for commodification, i.e. the fact that the respective content appears as a commodity. Both aspects will be pursued further in the following case studies.

The comparatively small and precise gestures on a touchscreen undoubtedly create a rather "intimate" (Verhoeff 2012: 85) experience compared to the sweeping gestures required by other popular forms of embodied interaction such as the *Wii Remote* controller or the *Microsoft Kinect* camera. Moreover, the touchscreen is closely connected to and revitalises existing topoi in media history

3 cf. https://play.google.com/store/apps/details?id=org.videolan.vlc.betav7neon&hl=en.

4 cf. http://techcrunch.com/2014/02/04/hands-on-with-facebook-paper/.

5 cf. http://www.urbandictionary.com/define.php?term=Swipe+right.

such as the notion of "immediacy" and the "'interfaceless' interface" (Kaerlein 2012: 178) by appearing "natural" and "intuitive" (ibid.). One should add that this impression is of course strengthened through inevitable comparisons with previous screen technologies and, in that context, emphasize the importance of seemingly mundane material parameters like scale, e.g. the gradual transition from 10-inch to 7-inch tablet screen sizes.

Adding to that, I am arguing that the materiality of touchscreens is conceptually related to physical modelling in the user experience (UX) design of the software and thus sustains the idea of touch-based interfaces as almost 'organic' extension of the user's body. Handwriting already constitutes a peculiar physical ensemble of the writer's body and its posture as well as the materiality of pen and paper, which has a distinct influence on the aesthetic quality of a writing style and is even used by graphologers to induce psychological characteristics. Similarly, the physical quality of operating a touchscreen has over time led to a number of changes in user interface design, most of which aim for physical continuity. The most prominent and widespread example of this is the so-called kinetic scrolling, according to which user inputs effectuates an 'impulse' on a digital page (e.g. a website in a mobile browser) that is gradually attenuated over time. Whereas for instance a computer mouse wheel allows for scrolling by a precise amount, touch-based kinetic scrolling affords a more casual 'exploration' of digital content.

Another example is the 'swipe-to-dismiss' gesture employed in applications like *Twitter*[6] or Reeder[7] that relies on simulated physical behaviour, such as UI elements bouncing back into place, in order to intuitively communicate its basic functionality and underlying logic to the user (without verbal explanation). Even more recently, in 2013, Amazon patented a system for *Gravity-Based Link Assist*[8], which is designed to help users interact with small UI objects on touchscreens by 'pulling' the pointer (i.e. the registered position of touch) toward nearby UI elements such as links or buttons. In the patent, Amazon argues that the technology might make touchscreens more inclusive and accessible to people with "declining health" or "injur[ies]"9. However, it also partially alleviates the fact that – due to material constraints of touchscreens – interfaces have become streamlined and rely more on spatial contiguity rather than trying to fit as many UI elements as possible onto the screen (as is the case e.g. with PC-based real-time strategy games that rely completely on the materiality of the computer mouse and, often, very light and highly sensitive gaming mice using high-CPI optical sensors.10 At any rate, if the patent should be implemented in a wide variety of software interfaces, it will naturalize the notion of touch pointers 'gravitating' towards UI elements and, thus, epistemically stabilise the UI as a quasi-material 'layer' between finger and hardware.

6 cf. http://thenextweb.com/twitter/2015/02/12/twitter-rolling-swipe-dismiss-images/.

7 cf. http://reederapp.com/ios/.

8 cf. e.g. http://www.wired.com/2013/03/amazon-patents-gravity-based-links/.

9 cf. www.google.nl/patents/US8386927.

10 cf. e.g. http://www.pcmag.com/article2/0,2817,2415385,00.asp.

Apart from these individual, application-specific examples, the logic of physical contiguity is embedded in the *Google Material Design Language* (GMDL) for 'apps', which has been formulated to foster a more unified user experience across different touch-based applications.[11] For instance, the section on animation first and foremost emphasises the importance of "authentic motion" governed by the "mass and weight"[12] of UI elements. That is, rather than simply understanding a touch-based application as a collection of "modular" (Manovich 2001: 30) elements, the GMDL ontologically implies a coherent simulation space that all elements are part of. This implied coherent space also manifests itself in (and is, in turn, defined by) other visual properties. For example, the GMDL characteristically envisions interfaces as 3D spaces[13], a design rationale that arguably can be directly traced back to the contingencies of touch-based interaction in combination with limited screen space. Accordingly, visual details like drop shadows are not integrated into the image itself but dynamically altered in response to the touch input, e.g. by differentiation between 'resting elevation' and 'responsive elevation'.

The GMDL functions as a combination of technical and social 'protocols' (Galloway and Thacker 2004: 14), i.e. as a set of "conventional rules and standards" (ibid.: 8) that exert decentralised control within Google's network of departments and third-party developers. These are built on a "material metaphor" that is "grounded in tactile reality, inspired by the study of paper and ink"[14]. Thus, this design approach aims to create an epistemic connection between the materiality of the touchscreen and the material quality of ink on paper. 'Materiality' is, in this case, understood as a common code that facilitates orientation: "The use of familiar tactile attributes helps users quickly understand affordances"[15]. This statement exhibits an acute awareness of physical contiguities, stating that the design should "supercede those [affordances] in the physical world, without breaking the rules of physics"[16]. Moreover, the design should afford user actions that "initiate motion" that "takes place in a single environment"[17], which again refers to the implication of a unified physical space.

The GMDL is thereby both incredibly detailed and specific, e.g. quantifying 'ideal' values and thresholds for parameters like the 'ease timing' of animated objects or the types of transitions. As Sinsabaugh (2014) argues, the GMDL underscores the fact that interfaces are increasingly becoming the locus of brand identity. However, while he refers to interfaces primarily as "pixels" (i.e. visual content), it is important to note in this context that, in the process,

11 cf. http://www.google.com/design/spec/material-design/introduction.html.

12 cf. http://www.google.com/design/spec/animation/authentic-motion.html.

13 cf. http://www.google.com/design/spec/what-is-material/objects-in-3d-space.html.

14 cf. http://www.google.de/design/spec/material-design/introduction.html#introduction-principles.

15 ibid.

16 ibid.

17 ibid.

also the specific materiality of touch-based interface conventions is increasingly 'branded', i.e. becoming a vital component of brand identities.

The relationship between 'embodied interaction' and the need for physical modelling on the software side can similarly be observed in the case of the *Nintendo Wii* controller, which also affords new material experiences (swinging one's arms, twisting and turning the controller). However, for these gestures to become naturalised among a broader audience, the interface needed to be complemented by physical modelling of the simulated character on the software side. In many games without contiguous physics, players quickly resorted to making only small, more efficient movements. Games like *Wii Sports*, on the contrary, that were built on inverse kinematics to 'interpolate' the avatar's movement based on player input intensified the 'perceived materiality' of the hardware and, thus, encouraged players to make more sweeping gestures.

Close-reading touch-based gestures

After investigating how the materiality of touch shapes production practices, the next step will be to consider the implications for media usage practices. Through a selection of small but interrelated 'close readings' of touch gestures, it is possible to make more specific claims about the implications of touchscreens[18] than the mere fact that they affect the epistemic difference between display and interface.

Some 'gestures' or patterns of touch control are only used in one particular application. For instance, the popular 3D modelling and sculpting tool *123D Sculpt* by Autodesk enables users to flatten a piece of 'virtual clay' or to rub decals onto the simulated surface via the iPad screen[19]. These forms of input can arguably be understood as 'remediating' the 'smudge' tool in *Photoshop* and similar image editing programs using the affordances of a coherent 3D space and touch control. However, as a 'blueprint' for similar types of investigations, the following case studies will focus on general purpose gestures like tapping, holding and swiping.

Tapping

Over time and through a conflation of different technologies, the simple touch or tap has been imbued with very different semantics, including highly specific practices like payment and authentication. By way of so-called "shoppable

18 An overview of currently conventionalized gestures can be found e.g. in the GMDL documentation at http://www.google.com/design/spec/patterns/gestures.html#gestures-touch-mechanics.

19 The official documentation video concisely illustrates these practices: https://www.youtube.com/watch?v=dIuRnaym_hQ.

touchscreens"[20], the tap signifies the confirmation of a transaction, similar to putting a signature on a piece of paper. The increasingly mainstream *Apple Touch ID* functionality has been used to further reduce friction in mobile payment processes but also allows for users to unlock their phones and, with the release of iOS8, has been opened up to third-party developers for use in all kinds of applications. Most importantly, though, it reinforces the aforementioned communicative quality of touch by technical means, i.e. at least by enabling user and device to mutually affirm awareness and recognition. Since all these semanticizations of tapping are becoming conventionalised over time, users learn what behaviour to expect from a surface based on the situation, similar to how digital games have conditioned players through the implementation of context-sensitive buttons.

On the other hand, the material affordances of touchscreens are being continually expanded. For instance, companies like *Qeexo* are working on the development of hardware that differentiates between a "fingertip, a knuckle, a fingernail, and a stylus"[21]. The rhetoric employed by the company's spokespeople thereby already hints at the underlying cultural idea of shaping an understanding of the human body according to the increasingly naturalised materiality of media hardware. For instance, CEO Sang Won Lee implicitly references button-based interfaces like a keyboard, mouse or gamepad arguing that using this type of screen will be "like having different buttons in your hand". Furthermore, the *Queexo* technology differentiates between different parts of the finger based on the minimal but characteristically different patterns of vibration they produce upon connecting with the screen. Thus, the implementation of the technology standard itself requires modelling 'touch' algorithmically, i.e. as distinctive patterns of data that allow for a sufficient threshold to be unambiguously discernible.

Apart from the single tap, double tapping has acquired several layers of connotation based on its use in different applications. The most prominent example is probably the fact that double-tapping on an image alternately increases the zoom factor and resizes the image again to fit the screen. Another characteristic and increasingly naturalised hybrid case is the selection of text on *Android* devices. Double-tapping on a word causes two markers to appear, which can be pulled into place to signify the start and end point of a text selection respectively. Compared to mouse input, this system is fairly cumbersome and counter-intuitive at first but it is, in fact, conceptually similar to UI conventions in the context of media manipulation, e.g. in linear video editing tools like *Avid* and *Final Cut* (Manovich 2007: 72/73) or audio editing tools like *Adobe Soundbooth* that work with timelines and sequences of clips. Thus, by virtue of touch-based interface constraints, text is intrinsically connoted as 'media material', which is indirectly manipulating through the proxy of 'clips'. Moreover, because the markers can only be moved line by line, the system confirms Kraemer and

20 cf. http://techcrunch.com/2013/11/20/ebay-debuts-shoppable-touchscreens-and-digital-storefronts-for-sony-toms-and-rebecca-minkoff-in-san-francisco/.

21 cf. http://www.wired.com/2014/06/qeexo/.

McChesney's observation of the dominant "belief in the one-dimensional nature of the written image as a linear series of letters" (Kramer and McChesney 2003: 520) instead of perceiving writing as a two-dimensional "order in space".

Holding and releasing

Holding down and releasing a finger from the touchscreen superficially appears like another form of tapping, but this gesture ultimately affords much more variety and characteristic forms of use. Usually, long taps are used as an equivalent to clicking the right mouse button in the sense that they often enable a menu with a contextual selection of options. This approach, trying to 'emulate' traditional control schemes using multi-touch, intrinsically points out the discrepancies between both input modalities, but also, if successful, increases mainstream usability by relying on familiar patterns. In a related matter, the long tap occasionally also signifies the idea of a 'deep' or more intense tap, i.e. of reaching 'into' the screen. For instance, the 'magnifying glass feature' used for text input on iOS-based devices uses the long tap to re-present going 'deeper' into the text; the scaled-up visuals emulate the material context of moving closer to the screen. While in this case, the duration of the tap is cognitively 'transcoded' into intensity, ongoing developments in the area of capacitive touchscreens promise to implement force-sensitivity into touch-based interfaces in the near future.[22] Similar to the aforementioned physical modelling in UI design, these developments will arguably make touchscreens feel more 'organic' in the sense that they 'mirror' (or rather: symbolically respond to) the intensity of touch as one of the most personalised and idiosyncratic forms of gestural communication. Moreover, force-sensitive displays will further complicate the relationship between touch controls and media aesthetics in the sense that their material constraints almost 'require' a layered, 3-dimensional UI paradigm similar to the propositions already built into the GMDL.

Yet, holding and releasing is a more flexible mechanic and affords more idiosyncratic forms of use as well as semantic variation than a mere long tap. For example, short-form video applications, following the example of *Vine*[23], allow for users to start and stop recording digital videos by touching and releasing the screen. This mechanic signifies an immediate (in the sense of Bolter/Grusin 2000) and tactile control of digital video material, affecting the ontology of the digital image itself. Correspondingly, the scrolling *Vine* website plays videos automatically when they come into view and stops them again when they aren't because it is optimised for swipe-scrolling and casual, exploratory browsing rather than targeted searching. It thus gradually institutionalises new perceptions of online video, which are still usually tied to the epistemic framework of a player or visible plug-in.

An even more iconic example is the press-and-hold gesture to view unopened pictures and videos in *Snapchat*. The application uses a mechanic similar to

22 cf. e.g. http://www.wired.com/2011/04/force-sensitive-touchscreen/.

23 cf. https://vine.co/.

Vine for its video chat: keeping a button pressed keeps the channel 'open', continually records and sends digital video.[24] More importantly though, users need to keep a button pressed to view so-called *Snaps*[25] in order to prevent users from creating screenshots of the supposedly 'disposable' traces of communication, which would compromise the service's value proposition. This (formerly) idiosyncratic use of the press-and-hold gesture is often regarded as a cornerstone of the application's success[26] and demonstrates a systematic endeavour on the behalf of app developers to 'playfully' engage with the material parameters of touch from the software side. This becomes also economically viable as the current standardisation of interface patterns already prompts the implementation of more unique, quirky and defining forms of touch control. For instance, the pinch gesture, which has been omitted from this case study, is re-semanticized in the *Spotify/iTunes* discovery tool *Sonarflow* by using the UI metaphor of bubbles that represent musical genres.[27] Thus, pinch navigation, which is normally used for zooming in and out of images or maps, is transformed into a different symbolic context and, thereby, acquires new layers of signification. These seemingly marginal forms of use will become more and more important as touchscreens give rise to a dedicated 'vocabulary' of tactile expression.

Swiping

Compared to short and long taps, swiping is an even more variable type of touch-based "design patterns" (Wigdor, Fletcher, and Morrison 2009: 2755). It is a reusable conceptual archetype that structures the development of software and, thus, also the actual algorithmic implementation of touch-based control.

Most prominently, the iconic 'swipe to unlock' gesture is used on many tablets to 'awaken' the device from stand-by mode. Practically, the gesture partially avoids 'accidental' activation but it does not provide the added protection of a more complex swiping pattern or password. To categorise this, it appears useful to transfer the notion of 'ornamental' design elements, which is usually associated with the visual aspects of the user experience (Page 2014), to touch interaction.

Due to its ornamental character the notion of swiping to 'bring a device to life' resonates with culturally formative topoi such as the 'spark of life' that is conveyed through touch in Michelangelo's *The Creation of Adam* or the myth of Pygmalion, in which an inanimate object is gradually 'made flesh'. As Harvey (2003) points out, Pygmalion's desire to touch is not merely sexual but an attempt to "touch language itself" (ibid.: 248/49). In this instance, the material quality of rhetoric (which also applies to digital content on a touch-based device) becomes apparent. This semanticization is reinforced through audio-visual

24 cf. https://support.snapchat.com/a/video-chat.

25 cf. https://support.snapchat.com/a/view-snaps.

26 cf. e.g. http://netzwertig.com/2013/11/15/snapchat-und-die-press-and-hold-geste-kleine-funktion-mit-groser-bedeutung/.

27 cf. e.g. http://www.sonarflow.com/sonarflow-1-6-4-gets-an-update/.

markers, i.e. a musical jingle, colourful particles emitted at the position of the finger and especially the fact that the transitional animation is directly tied to the swipe, i.e. the speed and intensity of the navigational gesture is directly mapped to the playback of the animation, all of which reinforce the semantics of 'coming to life'.

Another case that more aptly illustrates the relevance of "close-reading" patterns of touch-based interaction is *Swype*, a feature of the *Android* operating system that allows for entering text not by tapping on but by swiping over an on-screen keyboard. On-screen keyboards are 'limited' as simulations of an actual keyboard in the sense that they preserve the spatial organisation of the keys (if only in terms of the relative distance between keys) but not the tactile experience of their mechanical properties as buttons (Findlater and Wobbrock 2012). In that sense, *Swype* emulates more or less the same material parameters of writing on a keyboard but, upon using it for the first time, feels thoroughly unfamiliar because it 'transcodes' (in the sense of Manovich) the still highly naturalised materiality of writing on a keyboard (which itself is partially but not fully congruent with using a typewriter) into swiping gestures.

On that note, taking into account text input systems on earlier touch-based handheld devices like the *Palm Pilot* illustrates the relevance of a historically comparative perspective or at least an awareness of historical contingencies. Unlike techniques such as *Swype*, the so-called Graffiti system employed on these devices was based on 'handwriting recognition', i.e. a mode of input that substitutes the spatial organisation of letters as keys on a virtual keyboard with the spatial organisation of the characters themselves. It required users to write one letter 'on top of' the other on a small touch surface; moreover, every letter had to be represented by a (mostly) visually similar sign that could be drawn in one stroke and was easier to distinguish algorithmically. Because these seemingly arbitrary characters were not based on a familiar metaphor (like the virtual keyboard), they added a layer of 'hypermediacy' to the process of text input. This form of input can be partially explained by technological constraints but also by the cultural context of the devices and their designated target audiences. Because the Palm Pilot was primarily used for business purposes, the added inconvenience of using an arbitrary 'code' appeared more 'natural' and acceptable in such a closed ecosystem than it would on current touchscreen devices that reflect the logic and demands of consumer markets.

Apart from its connection to the physical contiguity of interfaces, the swipe gesture highlights another epistemic connection of the touchscreen with increasingly refined predictive algorithms and recommendation systems. Swiping-based interfaces characteristically present fewer but more specifically curated data entries. Thus, the swipe, which is often performed in a rather casual or even negligent way, signifies dismissing the currently presented content and usually 'serves up' the next best option. It emphasises the streamlined and thereby intensified dialogical relationship between user and taste profiling algorithms; instead of having to provide detailed feedback, the user only signals 'yes' or 'no', haptically underscored through the corresponding gesture. This interface logic plays to the psychological appeal of random rewards according to

B. F. Skinner, since this form of navigation is based on the compelling expectation of 'discovering' something particularly appealing with the next swipe. Thus, the gesture itself is over time strongly connoted with positive stimuli.

Predictive algorithms also come into play with regard to the aforementioned case of text input since typing on touchscreens is a constant feedback loop that cycles between intended input, actual input, algorithmically suggested corrections and adapted input and, thereby, conditions users to constantly refine their tacit understanding of the algorithm based on assessing its output. Clive Thompson terms these still often inadvertent forms of symbiotic engagement with algorithms in our everyday lives "cyborgian activity"[28] and, arguably, typing on touchscreen devices gradually makes this process observable through repeated use.

Given the small size of most touchscreens, a second distinct characteristic of swiping-based user interaction is the use of spatial metaphors and the negotiation between on-screen elements (i.e. those currently displayed) and 'off-screen' elements. A useful example to illustrate this implied spatial extension of the screenspace (Verhoeff 2009, 2012) is the mechanic for shutting down programs in the task manager, as implemented in recent versions of the *Android* operating system. The task manager displays concurrently running apps as a line of icons that can be scrolled via horizontal swiping if necessary. A vertical swipe removes the icons from the line (i.e. from the separate screenspace region) and, thus, shuts them down. The aforementioned *Tinder* is another salient example of a conceptually infinite (horizontal) off-screen space because new profiles are continually 'pulled in' from the *Tinder* database. By swiping left to dismiss and right to express satisfaction, *Tinder* employs the UI metaphor of having two spatially separate repositories that visualise the binary distinction. Similar metaphors are also explored in smaller context such as the travel-blogging application *Swapp*. Via swiping in one of the four main directions, users that publish on different channels can send the text to four predefined sources (apps) that are accessed by four different email addresses. That is, the swipe implies a spatial configuration of 'related apps' situated 'around' *Swapp* and thereby makes the underlying technical connection between apps through APIs and protocols 'tangible'. Most radically, the use of cards[29] as an integrative UX metaphor in recent versions of the *Android* operating system combines the predictive algorithms with the characteristic relationship between on-screen and off-screen spaces. Its plausibility and user acceptance can be directly traced back to the material constraints of especially small touchscreens; that is, the omnipresence of the touchscreen as the iconic interface technology of the contemporary media landscape arguably has long-term effects on the organisational logic of media devices and their operating systems. The implied distinction of on-screen and off-screen elements in touchscreen applications has already led to a tentative exploration of new forms of spatial contiguity, for instance in the form of gestures

28 cf. http://www.wired.com/2010/03/st_thompson_cyborgs/.

29 cf. e.g. http://netzwertig.com/2014/11/17/neudefinition-des-webs-karten-sollen-apps-und-websites-abloesen/.

that require swiping from outside the touchscreen itself (often referred to as 'edge swipes'). These gestures again point to the relationship between software (i.e. the algorithmic implementation) and the materiality of hardware in that they require border-less screens and are not compatible with earlier hardware due to that particular material constraint rather than technological specifications.

The case studies above repeatedly pointed to the fact that acknowledging the material qualities of touch interaction needs to be complemented by at least a cursory look at the software side, i.e. the contingencies of the actual algorithmic implementation or at least obvious algorithmic constraints. For instance, despite their omnipresence, swipe gestures are characteristically difficult to detect and, more importantly, are – in tabbed UI designs – 'reserved' for switching between tabs.[30] Thus, most basically, code related to touch-based interfaces exists on two 'layers', the operating system of the device and the individual application; the former thereby sits between the "levels" of code and platform (Bogost and Montfort 2007: 146). Even though users have no insight into the code, they gradually develop an approximative understanding of this distinction by experiencing it in subtle variations across different use cases.

To conclude, the (still ubiquitous) button has been identified as a symbol of the "*control* thought style in interface design" (Janlert 2014 [original emphasis]), which had become impractical with more complex "artifacts" and is being replaced by interfaces that allow for "expressing a specific request" (ibid.) from a predefined range of options rather that controlling a single parameter. As indicated by now seemingly anachronistic cultural 'texts' such as Steve Jobs' announcement of the original *iPhone*[31], the increasing adoption of touchscreens played into an already highly naturalised rejection of software functions being "fixed in plastic" (i.e. tied to physical buttons). Instead, the evolution of touch-based interfaces heralded a conceptual shift from hardware to software and established touch-based experiences as a unique combination of "mechanical hardware", "electronics"[32] and algorithms. The manifold uses of swipe gestures and the conceptual connection to recommendation algorithms identified above seem to sustain this assumption particularly clearly.

Outlook

The goal of this paper was to explore the materiality of the touchscreen by looking at how it is mediated through basic but iconic (and in some cases even evocative) algorithmically defined gestures. GMDL as a case study illustrates how touch-sensitive screens conceptually 'require' certain ontological changes, in this case a consistent three-dimensional and partially physically modelled

30 cf. e.g. http://www.androiduipatterns.com/2012/06/swipe-to-dismiss-coming-to-android.html.

31 cf. e.g. http://www.european-rhetoric.com/analyses/ikeynote-analysis-iphone/transcript-2007/.

32 cf. e.g. http://www.wired.com/2010/03/touchscreens-smartphones/.

screenspace that reflects the kinaesthetic experience on the software side. The second part of the argument focused on tapping, holding/releasing and swiping as the basic elements of touch-based interaction. Compared to traditional "affordances" (Dezuanni et al. 2015: 146-147) of mobile devices such as the size and weight or the built-in cameras, this perspective adds much-needed granularity to a media analysis of touchscreen.

Due to the scope of this paper, some aspects had to be left out for now. For instance, coming back to the notion of platform studies and the layers of digital materiality, operating systems tentatively represent an important intermediary layer, particularly because they are constantly updated and extended in the case of touch-based devices. Thus, an important agenda point for further research would be to investigate when and how iconic gestures such as pull-to-refresh[33] or the slide-in menu popularised by the mobile *Facebook* app become part of the underlying touchscreen API of the respective operating system. The platform studies perspective can furthermore be useful to consider hybrid cases like the *Samsung Galaxy Ace S5830* smartphone, which featured two capacitive buttons respectively for 'going back' a step and for opening a context-sensitive options menu, depending on the respective application. While touch input has been framed as an assemblage of material, electronics and software, the material level itself needs to be further differentiated. Through the omnipresence of touch-sensitive surfaces in all kinds of devices, basic material categories such as resolution, responsiveness and multi-touch capabilities (cf. e.g. Park, Kim, and Ohm 2014) become comparable in terms of their impact on the touchscreen experience.

A final important aspect that had to be omitted is the usage context of touch-based applications. For instance, in online forums, users express their appreciation of touchscreens in specific situations such as "browsing the web on the couch, [or] scrolling while cooking"[34]. These individual remarks point out how the technology, due to its material affordances, is integrated into everyday activities, i.e. to its specific 'apparatus' associated with more intimate social spaces like the living room or kitchen (Riggins 1994). Even though these practices appear marginal in and of themselves, they constitute additional puzzle pieces that ultimately yield a more complete picture. Despite indicating the importance of a historically comparative perspective, the case study focused on relatively recent and often *Android*-specific applications.

In a still fast-moving area of technological development, the categories put forth above can similarly be applied to technologies that are still in the planning stage and, through previews at trade fairs and promotional videos, shape the cultural imaginaries of the touchscreen as an artefact. Despite the economic stakes, the ongoing refinement of touchscreens and algorithmically defined interfaces has a distinctly playful character since it is impossible to predict which approaches will resonate in a particular cultural setting and result in viable products. This playfulness manifests itself through patent applications for inter-

33 cf. e.g. http://www.fastcodesign.com/3023421/why-the-pull-to-refresh-gesture-must-die.

34 cf. http://forums.imore.com/macbook-pro/321515-do-you-miss-touchscreen.html.

active tables[35], curved touch sensors and displays[36] or even haptic feedback, i.e. 'touch output'[37]. The "technological imaginary" (Lister et al. 2009: 66-67) – the assemblage of projected future forms and functions of the touchscreen – is also unfolded in academic discourse, e.g. by building on already formalised gestures like pinching to enable new forms of connectivity between applications (Ohta and Tanaka 2013). Complementary to this systematic exploration of material properties and gradual improvements, seemingly trivial but, taken together, culturally constitutive forms of using touchscreen are becoming more and more diverse.[38] Therefore, this paper aimed to provide analytical tools to investigate how, over time, the material and technical affordances are gradually translated into an expressive 'vocabulary' of touch.

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35 cf. https://www.google.nl/patents/US20070124370.

36 cf. www.google.nl/patents/US8603574 and www.google.nl/patents/US8808483.

37 cf. www.google.nl/patents/US8378797.

38 cf. e.g. the use of touchscreens to order food in a restaurant: http://www.wired.com/2008/06/is-touch-screen/.

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