# Influencing appraisals of emotional valence with spatial touchscreen interactions: An embodied approach to Positive Technology

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“We don’t just use technology; we live with it… interacting with technology involves us emotionally, intellectually and sensually. For this reason, those who design, use, and evaluate interactive systems need to be able to understand and analyze people’s felt experience with technology.” (McCarthy & Wright 2004, p.ix)

# Abstract

Could bodily interactions with touchscreen interfaces influence users' affective experiences? The present dissertation investigates, from an embodied perspective, the potential of touchscreen interfaces as "positive technologies". Positive Technology is an emergent research area within the fields of Cyberpsychology and Human-Computer Interaction interested in examining and promote the quality of user's affective experiences. However, despite touchscreens enable the manipulation of digital contents directly with the hands, very little is known about how such physical interaction may influence users' affectivity. This question was approached from theory and research on embodied cognition, which postulate that perception and action influence cognitive and emotional functioning. Specifically, it was considered the integration of (a) research on embodied interaction with touchscreen interfaces suggesting that manipulating visual contents (e.g., images) with directional interaction gestures (e.g., swiping) may stimulate their meaningful cognitive representation; and (b) experimental findings in psychology indicating that the processing of emotional valence is strongly associated with bodily dimensions of space and related directional arm movements (i.e., horizontal, vertical and sagittal). Against this background, right-handed subjects swiped positive and negative emotional pictures on a horizontal (Study 1), vertical (Study 2), and sagittal (Study 3) space of a touchscreen monitor. Concretely, it was examined if and how such interactions would influence subjects' affectivity as reflected in their valence appraisals towards the pictures. The crucial finding was that all studies revealed affective matchings between the pictures' valence category and the spatial touchscreen interactions, whereby these matchings mostly led to positive appraisals. Conversely, mismatchings generally led to negative appraisals. Positive Technology fields might benefit from these findings, which boundaries will be discussed in light of embodiment theory and action planning paradigms.

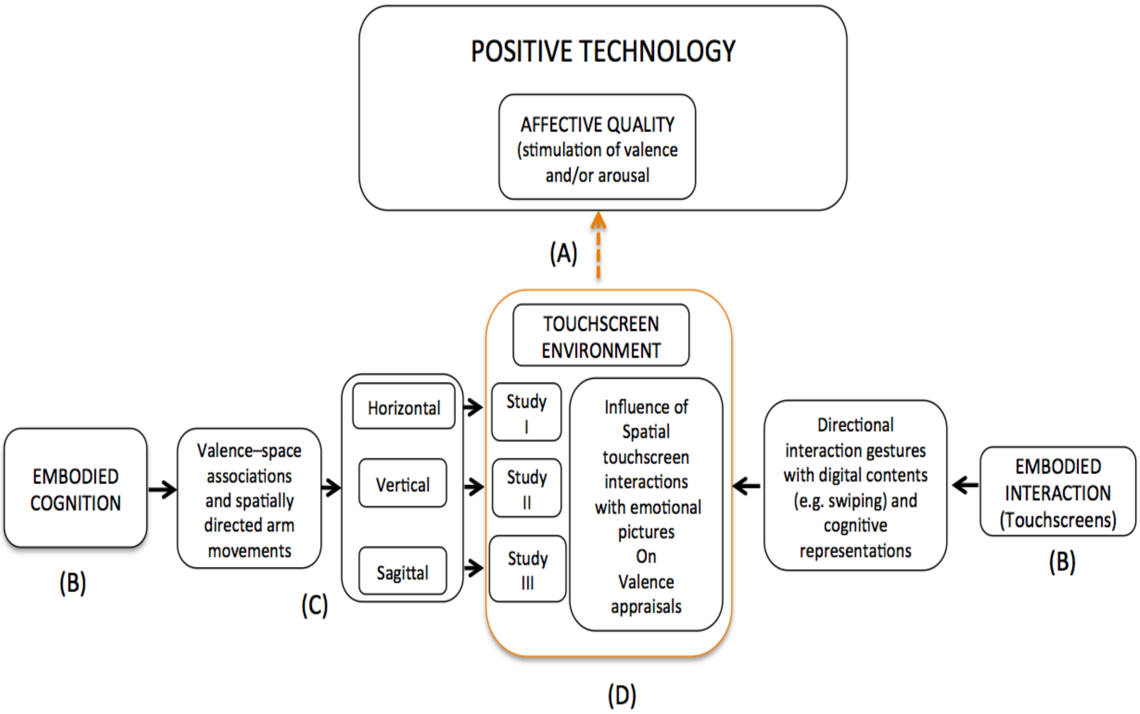


*Figure 1*. Schematic overview of the dissertation.

(A) Chapter one introduces affective aspects related to touchscreen environments and their potential connection with a Positive Technology approach-view. (B) Chapter two provides a general background on Embodied Cognition theory and research on Embodied Interaction with a focus on touchscreen environments. (C) Chapter three describes key experimental findings related to associations between emotional valence, bodily space, and spatially directed arm movements. (D) Building upon these findings, there will be reported three studies that have examined both if and how manipulating valence-laden contents with directional swipe gestures in a touchscreen environment could influence subjects' affectivity as reported in their valence appraisals of the stimuli. That will include results and a brief discussion for each study. The final chapter offers a general discussion integrating all the findings, highlighting potential applications, strengths, and limitations.

# 1. Touchscreens, affect and Positive Technology

## 1.1. Touchscreen interfaces as affective environments

Smartphones, tablets, or touchscreen monitors, and other interactive devices are becoming prominent elements in daily life activities, such as the access to the Internet, work or learning. The Global WebIndex's device survey (GWI) 2016, for instance, reported that about 90% of respondents from 34 different countries own a smartphone, 87% a laptop (including touchscreen monitors), 43% a tablet, and around three-quarter of internet users indicated that they go online via these devices.

Nevertheless, this "touchscreen trend" does not seem to be exclusively based on the pragmatic qualities and usability of these devices. Recently, research starts to show that emotion is a core aspect of user's experiences with interactive technologies (e.g., Kool & Agrawal, 2016). In particular, the advent and quick development of gesture-based interfaces such as touchscreens raises questions about how the use of these devices may be connected to users' affective experiences (e.g., positive and negative feelings or judgments; cf. Hassenzhal, Diefenbach, & Göritz, 2010; Hassenzhal, Wiklund-Engblom, Bengs, Hägglund, & Diefenbach, 2015). Disciplines such as aesthetics engineering (e.g., Liu, 2003) or emotional design (e.g., Norman, 2004), for example, are now concerned with the question of making interactive technologies more appealing and playful. In the words of Norman (2004, p.101) "technology should bring more to our lives than the improved performance of tasks: it should add richness and enjoyment."

In line with this notion, research shows that the aesthetic design of smartphones may influence the users' engagement with the device beyond software's features (e.g., Nanda, Bos, Kramer, Hay, & Ignacz, 2008), or even stimulate users' attachment to certain brands (e.g., Lee & Park, 2014). Additionally, there is a massive proliferation of interactive applications for entertainment, sometimes combined with novel techniques such as augmented reality, which embed virtual objects in real scenarios (e.g., Kari, 2016).

However, the use of touchscreens as platforms that facilitate access to information and communication through the Internet (e.g., social apps), may also lead to the excessive attachment to some of these devices, and abusive consumption of digital information, especially among children and teenagers (e.g., Gencer & Koc, 2012). Moreover, emotional drawbacks may arise when interacting with the interface become a strong desire, resulting in negative mood states or even health problems (e.g., Thomeé, Härenstam, & Hagberg, 2011). Against this backdrop, it seems that touchscreen interfaces incorporate playful and engaging qualities that may influence users' affective experiences in both beneficial and detrimental directions.

Interestingly, beyond playfulness or entertainment, new exciting questions are arising regarding how these technologies should be designed and used to support more adaptive experiences of emotional well-being. In particular, it is suggested that touchscreen interfaces have a critical potential to become "positive technologies" (Gaggioli et al. 2013). The next sections will describe what the term Positive Technology means and its potential relation to touchscreen interfaces from an embodied perspective.

## 1.2. Positive Technology

Positive technology is a scientific and applied research area within the Cyberpsychology and Human-Computer Interaction (HCI) fields. Its main purpose is to investigate and provide technological contexts useful to promote personal and social conditions of emotional well-being (e.g., Riva, Baños, Botella, Wiederhold, & Gaggioli, 2012; cf. Seligman, 2004). Concretely, this approach is interested in three main aspects of users' experiences with interactive technologies: connectedness, engagement and affective quality (Figure 2).

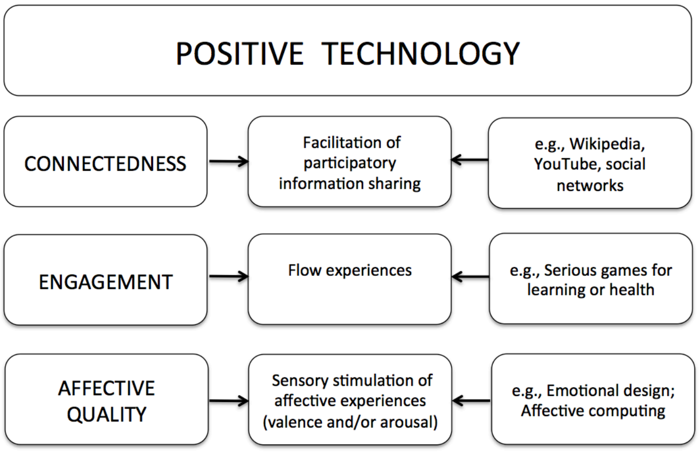


*Figure 2*. Three main targets in Positive Technology research (adapted from Botella et al., 2012).

a) Connectedness refers to the improvement of interpersonal relationships by facilitating access to the Internet and social networks, usually by means of interactive interfaces (e.g., smartphones; Kaplan & Haenlein, 2010). For example, social networks like Facebook, Twitter, or apps like WhatsApp and Telegram, among others, offer novel and flexible ways to share information and keep in touch with people. Additionally, smileys or stickers are original and important elements that help users to easily express affective states (e.g., Lee, Hong, Kim, Oh, & Lee, 2016). Interestingly, connectedness also includes more collaborative projects such as, Wikipedia, Crowd-funding, or Change.org, whose respective goals are to share knowledge, facilitate small economical contributions of a large number of people to fund a project, and facilitate social support for personal initiatives (e.g., laws to pursuit the abandon of animals).

b) Engagement refers to the search of mechanisms leading to optimal experiences (e.g., Finneran & Zhang, 2005). The key aspect of these experiences is that users may experience states of flow or balance between tasks demands and the required skills to accomplish said tasks (e.g., neither too boring nor too difficult; Ghani, 1995). These perceived states might result in cognitive effects such as concentration, motivation or creativity (e.g., Csikszentmihalyi, 2014). In line with this notion, tablets are transforming educational environments by facilitating the communication between students and teachers, and making possible the use of more dynamic contents, which may stimulate the students' motivation to learn (e.g., Ciampa, 2014; Furió, Juan, Seguí, & Vivó, 2015; Hassler, Major, & Hennessy, 2016). Furthermore, large-scale multi-touch tables are becoming attractive devices installed at museums or public exhibitions, supporting, in addition, collaborative group activities (Hinrichs & Carpendale, 2011; Hornecker, 2008). Another important aspect in this target area is the development of serious games. These games are designed for purposes beyond entertainment, for instance, to facilitate health care goals as a reinforcement of standard procedures such as medical/psychological treatments (e.g., Baños, Cebolla, Oliver, Alcañiz, & Botella, 2012; Conolly, Boyle, MacArthur, Hainey, & Boyle, 2012; McCallum, 2012).

c) The final aspect in positive technology research, and at the same time the most important for the present dissertation, concerns the use of novel interactive technologies as means to examine and promote the quality of users' affective experiences. Specifically, positive technology approaches consider that it is possible to examine the users' affectivity in terms of core dimensions of affect, namely, valence (i.e., positive/negative) and/or arousal (i.e., high/low activation or intensity; Russell, 2003). This requires usually the integration of valence-laden contents into multimodal digital environments, or in other words, environments that enable to exploit several sensory modalities (e.g., visual, auditive, haptic or kinesthetic; Botella et al., 2012). For example, virtual environments integrating valence-laden pieces of music, pictures, or even affective sentences (e.g., Clark, 1983; Richell & Anderson 2004; Velten, 1968) have been designed to stimulate positive or negative affective experiences when users are virtually immersed in such scenarios (e.g., Baños et al., 2005; Felnhofer et al., 2015; see Figure 3).

*Figure 3*. Illustration of virtual parks designed to stimulate negative affect (left part) or positive affect (right part; adapted from Baños et al., 2005).

Consistent with this idea, some studies are implementing interactive applications for touchscreens (e.g., games) directed to investigate the stimulation of positive affective states (e.g., joy; Robinson, Grillon, & Sahakian, 2012) or to examine emotional regulation strategies upon negative affective states (e.g., frustration; Rodriguez et al., 2015; Vara et al., 2016). Nonetheless, these studies do not truly focus on the affective influence of a bodily interaction with the interface, but rather on the integration and use of affective contents within the interface. In recent years, however, there has been an emerging interest from the Human-Computer Interaction fields on how interactive devices such as touchscreen interfaces may help to detect users' affective experiences by means of bodily feedback (i.e., Affective computing; Picard, 1997; see Poria, Cambria, Bajpai, & Hussain, 2017 for a review). Some of these studies will be described next.

### 1.3. Detecting affect with touchscreen interactions

In line with positive technology approaches, some studies have started to investigate whether haptic (e.g., touch) or kinesthetic (e.g., movement) sensory modalities related to interactions with touchscreen interfaces may serve to detect users' affective responses (e.g., Lee, Chang, & Cheng, 2014; Park, Lee, & Kim, 2011; Shah, Teja, & Bhattacharya, 2015). For example, Gao, Bianchi-Berthouze and Meng (2012) used a touchscreen-based gameplay to investigate whether sensory features associated with the participants' finger strokes (e.g., pressure, speed, direction or length) would correlate with their reported affective responses. These responses were coded in terms of emotional valence (i.e., positive/negative) and arousal (i.e., high/low). The crucial findings indicated that the tactile pressure on the interface correlated better with the reported states of frustration (i.e., negative valence – high arousal) compared to excitement or relaxation (i.e., positive valence – high or low arousal respectively). On the other hand, speed and directedness discriminated better the arousal levels of frustration and excitement compared to relaxation or boredom (i.e., negative valence – low arousal). In addition, states of boredom were reflected in shorter finger' strokes length. In other words, according to these findings touch' pressure was useful to detect users' negative valence states compared to positive ones, whereas speed served to discriminate high versus low arousal. Recently, the study by Dai, Liu, and Meng (2016) has also reported similar effects but using a different procedure. Specifically, they presented emotional pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997) on a monitor screen. Then, after watching the pictures, participants were asked to interact with a touchscreen device freely. The recorded data suggested higher pressure and speed correlated with the participants' fingers strokes, subsequent to the observation of negative pictures when compared to positive pictures.

In summation, the just described studies highlight the relevance of sensory aspects for the detection of user's affectivity; positive or negative affective experiences may influence physical touchscreen interactions (e.g., affect influence on finger' strokes), which, in turn, are reflected in sensory features such as pressure or speed.

However, it may appear that there is a gap between research integrating positive or negative emotional contents within interactive applications and research that examines sensory modalities connected to affect. In other words, considering that users can manipulate digital contents with fingers-, hands- or arm moving gestures in these devices, it seems conceivable that beyond detection, different bodily interactions with valence-laden contents might lead to different affective responses as well. From the viewpoint of Positive Technology, such influence, particularly when interacting with valence-laden contents, could provide new insights regarding how to enhance the quality of users' affective experiences in touchscreen environments. That leads to a pivotal question: Could it be possible to deploy interaction gestures useful to influence users' affectivity?

The present dissertation proposes to shed light on this issue from an embodied cognition theoretical-view, which postulates that bodily activity is tightly bound to cognitive and emotional experiences. Specifically, the next chapters will draw a general background on embodied cognition theory. Then, to put things more concretely, it will be considered the integration of two relatively unconnected lines of research with regard to the study of users' affectivity, in spite of their common framing in embodied cognition accounts.

On one side, some applied fields from psychological and computer science address the term "Embodied Interaction" to investigate cognitive effects stemming from physical interactions with interactive technologies (e.g., Antle, 2013; Dourish, 2001; Farr, Price, & Jewitt, 2012). In particular, recent studies using touchscreen interfaces suggest that interaction gestures with digital contents may facilitate not only their visuospatial processing but also their cognitive representation (e.g., Brucker, Ehrmann, Edelman, & Gerjets, 2016; Kranz, Imhof, Schwan, Kaup & Gerjets, 2012; cf. Widgor & Wixon, 2011). Nevertheless, literature in this domain is very scarce about the study of users' affectivity.

Interestingly, on the other side, experimental research in psychology indicates that the mental representation and processing of valence-laden stimuli may be associated with spatial dimensions of the body (i.e., horizontal, vertical and sagittal; cf. Crawford, 2009; Milhau, Brouillet, Heurley, & Brouillet, 2012), which has also been reflected in directional hand or arm movements. In this case, however, very little is known about the influential role that these associations may play on users' affectivity, especially if they manipulate valence-laden stimuli in a touchscreen environment.

# 2. Embodied cognition and embodied interaction

## 2.1. Embodied cognition

Interdisciplinary fields including computer science (e.g., Marocco, Cangelosi, Fisher, & Belpaeme, 2010), cognitive psychology (e.g, Gozli, Chow, Chasteen, & Pratt, 2013), social psychology (e.g., Meier, Schnall, Schwarz, & Bargh, 2012) and neuroscience (e.g., Meteyard, Cuadrado, Bahrami, & Viggliocco, 2012), among others, give support to the embodied cognition theory. This theoretical perspective postulates that perception and action play a fundamental role in our cognitive and emotional functioning (e.g., Glenberg, 2010; Wilson, 2002; Winkielman, Niedenthal, Wielgosz, Eelen, & Kavanagh, 2015). In a more specific way, it is suggested that cognitive or affective knowledge (e.g., language or memory) involves the partial reactivation of sensorimotor neural systems (e.g., vision, audition, touch or movement), which are present when perceiving or interacting with the objects or entities this knowledge refers to. This neural reactivation is what is believed to generate a mental representation or simulation (e.g., Barsalou, 1999; Gallese, 2003; Lakoff & Johnson, 1980). An illustration may help to clarify this notion. Thinking in a monkey or reading the word "monkey" may stimulate a mental image or simulation of a monkey based on perceptual and physical features that one may know about monkeys such as the sounds they make, color, morphology, or movements. Moreover, it is possible for the word "monkey" to evoke a positive or negative feeling connected to a past experience with a monkey.

Research in neuroscience supports aspects of the embodiment theory by reporting that neural substrates in the motor cortex, coined as mirror neuron system, fire in both, action perception and action performance (Ferrari & Rizzolatti, 2014; Rizzolatti & Craighero, 2004). At a behavioural level, some studies have shown, for instance, that the mere observation of images depicting objects with handles may activate grasp-like motor responses (e.g., Tucker & Ellis, 2004). Other studies report action compatibility effects by which subjects process the meaning of an action-sentence faster (e.g., "close the drawer") when they perform an arm movement that match with that action (e.g., a forward arm movement; Glenberg & Kaschak, 2002).

Interestingly, the relationship between bodily activity and the processing of information is thought to be bidirectional and is especially remarkable in the case of emotion (e.g., Niedenthal, 2007). On the one hand, affective information may influence bodily responses (i.e., affect-to-action link). For example, the study by Dai et al. (2016) described in Chapter 1, showed that observing positive or negative emotional pictures influenced the way participants performed finger' responses on a touchscreen device. On the other hand, bodily activity may influence affective responses (i.e., action-to-affect link). This has been reflected, for example, in valence appraisals towards presented stimuli (e.g., Clore & Schnall, 2008). Positive stimuli (e.g., cartoon figures) are typically evaluated more positively if subjects exhibit "smiling" facial expressions, but negative stimuli are more negatively evaluated if subjects exhibit "frowning" expressions (e.g., Havas, Glenberg, & Rink, 2007). In general, embodiment approaches to emotion suggest that when bodily activity (e.g., postures or movements) is congruent with the mental representation of affective information, the processing of said information may be facilitated (e.g., Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009). Indeed, this assumption drives the purpose of the present dissertation; especially the question of how bodily activity influences an affective experience in a touchscreen environment (i.e., action-to-affect link). Moreover, from a Positive Technology framework, the manipulation of valence-laden contents with direct hand or arm interactions becomes of crucial relevance. Let us say that if a positive or negative content displayed on a touchscreen acquires a different meaning or is differently processed by its physical interaction, that it could be highly relevant to understand or even enhance the quality of a user's affective experience.

Therefore, the question arising next is how these interactions should be performed in a touchscreen environment in order to influence users' affectivity. In line with the embodiment approaches to emotion, could it be possible to perform interaction gestures that match with the mental respresentation of affective information?

To approach to this issue, however, it may be useful to first know which potential mechanisms come into play when manipulating digital contents in a touchscreen environment. In this regard, some embodiment approaches to interactive technologies such as touchscreens suggest that performing interaction gestures that match with the depiction of presented contents, may lead to a meaningful and richer content' processing. This approach addressing the term of Embodied Interaction will be described next.

## 2.2. Embodied Interaction

The concept of Embodied Interaction was introduced in the field of computer science to emphasize the idea that users' not only are able to perform bodily (inter-) actions with interactive technologies but also that they integrate knowledge and meanings stemming from their experiences in the physical world (e.g., Dourish, 2004; Garg, 2012). According to Jacob et al. (2008) this knowledge could be structured in more concrete physical dimensions. For example, the authors coined the term Reality-Based Interaction (RBI) to suggest that when using interactive technologies, users may integrate the understanding of basic laws of physics like distance, pressure, velocity and also spatial relationships between the objects. On the other side, they may also integrate understandings of haptic and kinesthetic sensory modalities related to the manipulation of physical objects, and the position or movement of their own body in the space. Social awareness may also be influential, for example, when groups of people collaborate in tasks performed on large-scale multi-touch tables (e.g., Morris, Huang, Paepcke, & Winograd, 2006).

Interestingly, considering that in touchscreen environments the digital contents (e.g., texts or pictures) may be displayed at different locations or can be manipulated differently across the screen space (e.g., zooming, tapping or swiping), recent evidence demonstrates that interaction gestures with touchscreens are richer and meaningful when they are deployed in congruence with the visual depiction of a digital content (i.e., Gestural conceptual mapping; Segal, 2011). For example, performing a continuous interaction gesture on a horizontal line displayed on a tablet resulted in better estimation of a number's position on the line compared to a discrete tapping gesture on the same line (e.g., Dubé & McEwen, 2015; Segal, Tversky, & Black, 2014; Figure 4).

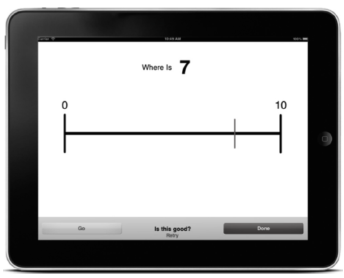


*Figure 4.* Representation of the number-line estimation task on a tablet (adapted from Dubé & McEwen, 2015).

This finding suggested that performing an interaction gesture that congruently matched with the depiction of the digital contents in the task (i.e., continuous interaction gesture – line) facilitated the mental representation of abstract relations between numbers and space, thus enhancing the cognitive processing of the number's position. Nevertheless, beyond numbers, these effects seem also to apply to other kinds of visual contents such as pictures. For example, participants were asked to sort art pictures displayed on a multi-touch table into different boxes representing art categories (e.g., classic art picture – classic box category). The sorting action was performed either by touching and moving the images on the device, from their initial location to a final location indicated by the boxes (i.e., swipe gesture condition; see Figure 5) or by directly tapping on the boxes, hence, the images moved to the selected category without touching them directly (i.e., tapping gesture condition). The results showed that performing swipe gestures led to higher accuracy in the sorting task compared to the tapping gestures. The authors interpreted this finding to indicate that performing interaction gestures with the pictures across the touchscreen space conveyed a meaning similar to physical actions of moving and placing real objects, thus, leading to a better processing of the images' content and their spatial relations with their category (Kranz, Imhof, Schwan, Kaup, & Gerjets, 2012).

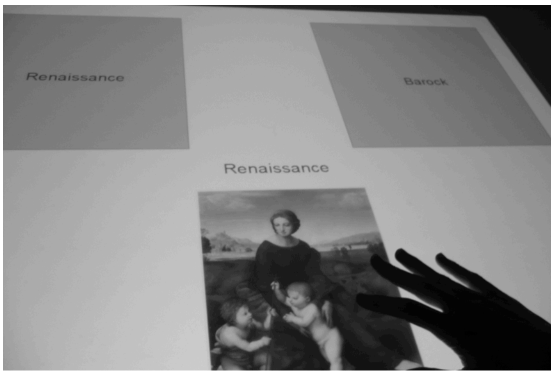


*Figure 5.* Representation of the swipe gesture condition in Kranz et al., (2012).

Therefore, according to these findings, one may conclude that on one side, different sensory modalities like visual, haptic or kinesthetic can be integrated through meaningful interaction gestures with digital content on a touchscreen space (e.g., swiping). On the other side, the congruent match between interaction gestures and the presented content (e.g., numbers or images) may stimulate representations of the content in terms of their spatial relations (cf. Jacob et al., 2008), thus facilitating their cognitive processing.

Nevertheless, the just mentioned findings do not relate directly to users' affectivity, as is the main focus in the present dissertation. However, they do strongly connect with experimental findings highly relevant in touchscreen interactions; the hand proximity to a visual stimulus may facilitate their visuospatial processing, which may also include the processing of emotional contents (e.g., Abrams, Weidler, & Suh, 2015). This effect, known as near-hand effect, will be described next.

## 2.3. The near-hand effect

According to Abrams, Weidler, and Suh (2015; p. 142) "the space near the hands is special. The importance of the near-hand space arises, in part because of the potential that hands possess to interact with the objects around us […]. For these reasons, the mental mechanisms that process the space around the hands have become especially tuned to the important purposes by the hands."

Supporting this idea, experimental findings have shown that: a) visual stimuli displayed in close proximity to the hands benefit from visual attentional resources and b) this attentional benefit may influence affective experiences when processing valence-laden stimuli near the hands.

a) Visuospatial attention near the hands

Schendel and Robertson (2006) conducted one of the first studies that gave rise to the near-hand effect. They found that a patient with visual damage in the left visual field experienced reduced related blindness in that field when he was asked to detect stimuli displayed on a monitor screen. Specifically, this effect was found only when the subject extended the left arm toward the monitor, suggesting that having the hand in close proximity to the displayed information reinforced attentional processes in the damaged field. Building upon these findings, further studies have reported that participants with normal vision detected stimuli presented at the left or right space of a monitor screen faster when they held a hand extended toward the stimuli (i.e., near – hand condition) compared to when they left the same hand in a resting position far from the monitor (i.e., far – hand condition; Reed, Betz, Garza, & Roberts, 2010; Reed, Grubb, & Steele, 2006). However, to rule out the hypothesis that these effects were due to a visual bias related to the space where the stimuli were presented, researchers have also demonstrated that stimuli presented simultaneously in the space between the both hands are visually prioritized, leading to a more intense evaluation. For example, Abrams, Davoli, Du, Knapp, and Paull (2008) instructed participants to detect two targets consecutively presented on a monitor screen (e.g., numbers and letters). To do so, participants either held both hands at the left-right sides of a monitor screen (i.e., near – hand condition) or held their hands in their laps (i.e., far – hand condition; see Figure 6).

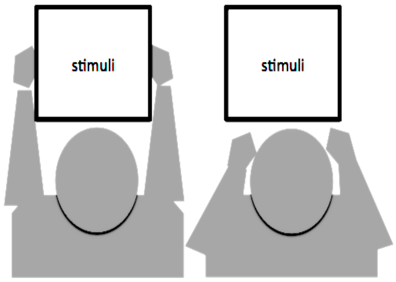


*Figure 6.* Depiction of an experimental setting with participants in the near-hand condition (left side), and participants in the far-hand condition (right side; cf. Abrams et al., 2008).

The results suggested that subjects in the near-hand condition stimulated a mechanism of inhibition of attentional disengagement. This means that these subjects prolonged the visual processing on the first target, thus, leading to less accurate detection of the second target compared to subjects in the far–hand condition.

Indeed, further findings stemming from research on neuroscience seem to support a specific visuospatial processing near the hands. It has been proposed that having stimuli near the hands stimulates multimodal neurons with receptors sensitive to visual and tactile stimulation. Moreover, it is suggested that these neurons could encode the visual space around the hands (around 20-30 cm; Holmes & Spence, 2004). For example, Graziano, Yap & Gross (1994) reported bimodal neurons in monkeys (i.e., with haptic and visual receptors) that fired when visual stimuli were near the hand (see also Grazziano, Gross, Taylor, & Moore, 2004). Furthermore, neuroimaging studies suggest that such multimodal neurons might be present in the human brain too (Macaluso & Maravita, 2010).

2.3.1. Near-hand effect in embodied touchscreen interaction

In line with the above-described findings and especially with embodied touchscreen interaction research, recent evidence has been provided that near-hand effects may also arise when interacting with stimuli on a touchscreen interface, hence, integrating both visual and haptic modalities. Concretely, Brucker, Ehrmann, Edelman, and Gerjets (2017), examined whether the direct (vs. indirect) manipulation of digital objects on a large-scaled multi-touch table would influence their related content processing. To do so, they presented art pictures and texts displayed on the multi-touch table. Participants either had to touch and move the pictures from initial locations towards ending locations indicated by empty boxes (i.e., near – hand condition), or to move them indirectly towards the boxes by means of placeholders (see Figure 7). Therefore, both groups performed similar directional movements, with one group touching the objects directly with their hand and the other doing so indirectly. At the end of the experimental session participants completed a multiple-choice test about the objects. The findings indicated that participants who touched and moved the digital objects directly (i.e., near – hand condition) performed better on the multiple-choice test compared to the group that used the placeholders. Nonetheless, while this effect was found for the pictures, it was not found in the text condition, which is in line with former findings suggesting that the near-hand effect impairs the processing of semantic information (Davoli, Du, Montana, Garverick, & Abrams, 2010).

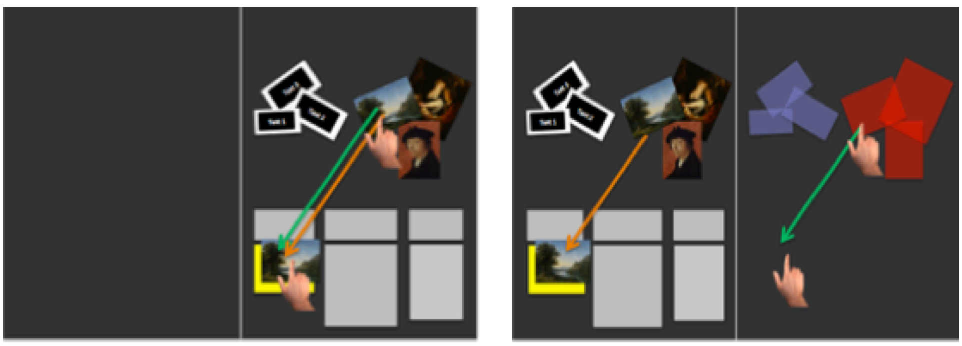

*Figure 7*. Depiction of the experimental setting in Brucker et al., (2017). Left part: direct hand interaction with digital images (i.e., near-hand condition). Right part: inditerct interaction with digital images (i.e., far-hand condition)

However, could it also be that valence-laden visual stimuli benefit from attentional enhancement due to the hand proximity? Recent evidence points in this direction.

b) Processing valence-laden stimuli near the hands

Recent evidence suggests that the visuospatial processing of affective stimuli displayed near the hands may influence affective experiences. In a study by Rahona, Ruiz-Fernández, Lachmair, & Gerjets (2017), positive emotional pictures were presented on a monitor screen subsequent to the participants' induction of a negative affective state (i.e., by listening negative connoted music). The experimental task consisted of simply observing the pictures. Half of the participants held both hands on the monitor sides (i.e., near – hand condition), whereas the other half held their hands in a resting position (i.e., far – hand condition; see Figure 4). The results revealed faster mood recovery in the near-hand (vs. far-hand) condition, suggesting that the participants deployed higher visuospatial attention to the positive pictures, hence, leading to higher stimulation of positive affect.

Against this background, one might argue that, as suggested in the near-hand effects reported by Brucker et al. (2017), touching directly valence-laden stimuli on a touchscreen interface (e.g., swiping emotional pictures) could potentially deploy higher visuospatial attention to their content (e.g., positive or negative valence). Interestingly, beyond near-hand effects, Bruker et al., tackled another important aspect highlighted in embodied interaction research: interaction gestures involving touching and moving stimuli from their initial location to an end location on a touchscreen space (e.g., swipe gestures) compared to discrete tapping gestures, may facilitate not only the processing of the stimuli' content but also their visuospatial representation (e.g., Kranz et al., 2012; Segal, Tversky, & Black, 2014). Accordingly, both, the visuospatial processing near the hand, and spatially directed arm gestures, might be mechanisms with the potential to influence users' affectivity during touchscreen interactions with valence-laden stimuli.

However, up to this point, it cannot be clearly stated whether interacting valence-laden stimuli in a touchscreen environment (e.g., emotional pictures) may influence their valence processing or, in turn, the users' affectivity. Moreover, swiping interactions with digital contents could be performed in very broad different directions; thus, it is still unclear how these gestures should be performed or how the stimuli should be displayed. Interestingly, one possibility to approach to this question stem from experimental research in psychology framed in embodied cognition accounts. As elaborated in the next chapter, some embodied approaches to emotion consider that the mental representation of emotional valence is grounded in bodily dimensions of space (i.e., horizontal, vertical and sagittal). Indeed, experimental paradigms requiring the performance of directional arm movements along these spatial dimensions suggest that the congruent match between a performed movement and the mental respresentation of valence-laden stimuli may be relevant for the processing of said stimuli. This highlights an interesting parallelism with the above-described findings in embodied interaction research where interaction gestures that matched the depiction of a content led to the improved visuospatial processing of said content. Therefore, the integration of these two approaches will serve as motivation for the studies presented here.

# 3. Valence – space associations and spatially directed arm movements

## 3.1. Grounding emotional valence in the body space

As introduced in chapter two, embodied cognition approaches suggest that sensorimotor experiences may ground the mental representation of more abstract information (e.g., language; Barsalou, 2008). Along with this line of reasoning, some embodiment accounts postulate that sensorimotor experiences may also ground mental representations of positive or negative emotional valence (e.g., Johnson, 2008). In particular, such representations might be associated with spatial dimensions of the body (i.e., body schemas: horizontal, vertical, and sagittal; cf. Milhau, Brouillet, Heurley, Brouillet, 2012). For example, the use of colloquial expressions such as "you are my right hand", "I feel down" or "they are close friends" may indicate the mental representation of more abstract concepts such as relevance, sadness, or friendship by binding, in metaphorical terms, abstract information like positive or negative affect with physical dimensions of space (i.e., Conceptual Metaphor Theory; Lakoff & Johnson 1980; Lakoff, 2014). The rationale behind this idea is that experiencing affect involves systematic patterns of bodily activity stemming from effectors like the hands, arms, feet, legs, and head, which we use to interact with the physical space (i.e., right-left; up-down, and front-back; Crawford, 2009; cf. Gallese & Lakoff, 2005). For example, as elaborated in the next sections, the associations between emotional valence and the horizontal space (i.e., right/left) may stem from the motor fluency related to the dominance or non-dominance of bodily components such as the hands. The associations with the vertical space (i.e., up/down) relate to physical manifestations of emotional states. As an illustration, people may raise both arms effusively to express joy when their favourite sports team scores, whereas experiencing sadness may be reflected in bodily postures such as when sinking the shoulders and in addition bringing the head down. Finally, associations with the sagittal space (i.e., front/back) may be connected to approach-avoidance behavioral tendencies. Based on these valence-space associations, experimental research has reported affective matchings between the processing of valence-laden information (e.g., words or pictures) and their presentation at those spatial dimensions, resulting these matchings in faster processing of said information; more importantly, research has also reported affective matchings between presented valence-laden stimuli and performed spatially directed arm movements. In the coming passages, such evidence will be structured according to valence associations with the horizontal (i.e., right – left), vertical (i.e., up – down), and sagittal (i.e., front – back) dimensions of the bodily space.

## 3.2. Valence associations with the horizontal space: hand dominance

Metaphorical expressions like "you are my right hand" or "I've got two left hands" might indicate respectively the mental representation of positive connoted concepts such as "relevance" or negative connoted concepts such as "clumsiness". Interesetingly, the role played by the hands in the mental representation of emotional valence may be traced from their use in real physical interactions. Concretely, the Body Specificity Hypothesis (BSH; Casasanto, 2009) proposes that right-handers associate the space surrounding the dominant right hand (i.e., dominant right space) with positive valence because of the greater motor fluency of the right hand within the right space. In contrast, right-handers associate the space surrounding the non-dominant left hand (i.e., left non-dominant space) with negative valence.

Left-handers, on the contrary, would exhibit the opposite pattern (i.e., left space – positive valence; right space – negative valence).

In order to demonstrate these valence-space associations Casasanto devised a series of forced-choice experiments. For example, when asked to assign positive or negative stimuli (e.g., animal cartoons) into the left or right sides of a sheet of paper, right-handed participants tended to assign positive stimuli into the right space but negative stimuli into the left space. Furthermore, in a different task, right-handed participants evaluated neutral stimuli (e.g., descriptions of job offers) presented in the right space on a sheet of paper as more positive, but stimuli presented in the non-dominant left space as more negative. As predicted, left-handed participants showed the reversed pattern in both tasks. In general, the explanation for these findings refers to the assumptions that, first, the dominant hand interacts more fluently within its own space (e.g., Carey, Hargreaves, & Goodale, 1996), and second this motor fluency is positively connoted (e.g., Beilock & Holt, 2007; Winkielman & Cacioppo, 2001; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). In line with this notion, Hayes, Paul, Beuger, and Tipper (2008) showed that right-handers evaluated the valence of affective neutral objects more positively in a numerical scale (e.g., tissues or kitchen utensils). This effect appeared subsequently to moving the objects from the right to the left or the left to the right locations on a table; but only when the movements were performed without the interference (vs. with interference) of an obstacle (e.g., a vase filled with water). Thus, the positive marking of the motor fluency associated with lateral movements performed without an obstacle resulted in more positive ratings towards the neutral objects.

Interestingly, building upon the BSH, other studies have reported associations between emotional valence and motor responses of the hands, which might be highly relevant for the processing of valence-laden stimuli in touchscreen environments. Specifically, it has been shown that the processing of valence-laden stimuli is associated with: a) motor responses of the dominant and non-dominant hand in the right and left space, and b) lateral arm movements to the right or to the left. Both will be elaborated in the coming passages.

a) Motor responses of the dominant and non-dominant hand in the right and left space

In line with the BSH, de la Vega, Filippis, Lachmair, Dudschig, and Kaup (2012; see also Kong, 2013), examined whether the processing of positive or negative stimuli was associated with motor responses of the non-/dominant hand. Specifically, right-handed participants were instructed to judge the positive or negative valence of words presented in a centered position on a computer screen. To do so, they responded with their dominant right hand by pressing a key at the right side of a keyboard and with the non-dominant left hand by pressing a key at the left side (see Figure 8). The results revealed that participants responded to positive stimuli faster with their dominant hand (i.e., on the right side) and also to negative stimuli faster with the non-dominant hand (i.e., on the left side). Left-handed participants showed the reversed pattern. This findings suggested a valence – space motor compatibility effect supporting the BSH. Specifically, the authors explained such effect as an affective match between the stimuli' valence category and the valence associated to the dominant space (i.e., positive word – positive right space; negative word – negative left space). However, in a follow-up study de la Vega, Dudschig, De Filippis, Lachmair, and Kaup (2013) demonstrated that when right-handers crossed the hands on the keyboard (e.g., dominant right hand responding on the left side and non-dominant left hand responding on the right side; see Figure 8) they still showed responses to positive words faster with the dominant right hand and to negative words faster with the non-dominant left hand. The conclusion of de la Vega and colleagues was that the effects represented an affective connotation of the hands (i.e., dominant right hand – positive and non-dominant left hand – negative) rather than an affective connotation of the spatial locations where the hand responses took place.

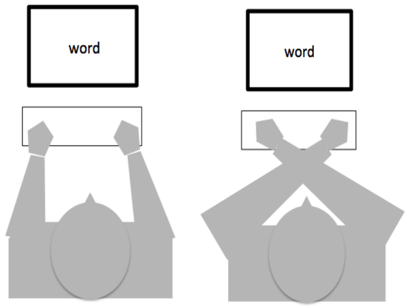


*Figure 8*. Depiction of experimental settings with participants responding to valence-laden words by means of a) right/left hands placed at the right/left space of a keyboard (left part; cf. de la Vega et al., 2012), or b) responses to the words with the hands crossed over on the keyboard (right part; cf. de la Vega et al., 2013).

Nevertheless, in addition to these findings it has been proposed that such hand – valence connotation is not entirely fixed, and it can be modulated when performing lateral arm movements to the right (rightwards) or to the left (leftwards).

b) Lateral arm movements to the right or to the left

To further explore the hand – valence connotation proposed by de la Vega et al. (2013), a study by Milhau, Brouillet, and Brouillet (2015) indicated that processing the valence of a stimulus was also associated with the motor fluency related to a performed lateral arm movement (i.e., leftwards vs. rightwards). In their study participants were asked to judge the valence of positive or negative words presented in the middle of a computer screen by means of keypresses on a keyboard. This time, two groups of right-handed participants judged the valence of the words by responding only with their dominant right hand, whereas two further groups used only their non-dominant left hand (see Figure 9). Additionally, half of the participants responded to the positive or negative words by releasing a key at a centred position of the keyboard and pressing respectively a key at the right or left side. The other half responded to the positive or negative words by pressing respectively a key on the left or right side. Therefore, participants performed a rightward or leftward arm movement in order to judge the stimuli. The crucial finding was that positive words were judged faster with movements of the dominant right hand to the right side but also with the non-dominant left hand to the left side. A similar pattern of results was observed for left-handed participants. The authors interpreted these results to indicate that rather than fixed, the affective connotation of the hands can be modulated by the motor fluency associated with the lateral movements performed in a task (cf. Casasanto & Chrysikou, 2011).

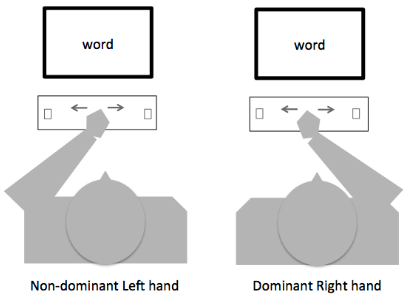


*Figure 9*. Depiction of an exprimental setting with participants responding to valence-laden words by performing lateral arm movements (rightwards or leftwards), either with the left hand (left figure) or the right hand (right figure; cf. Milhau et al., 2014).

Against this backdrop, one may argue that processing the valence of an affective stimulus would be congruently associated with affective motor responses of the dominant and non-dominant hand (de la Vega et al., 2013), or in contrast, with affective lateral movements of the hands to the right or left space (Milhau et al., 2015). However, how could these findings tie to the potential influence of user's affectivity on a touchscreen environment? First, in those studies, participants did not manipulate the stimuli with the hands. Furthermore, these studies focused on how the processing of valence-laden stimuli was associated either with motor responses of the hands or with peformed lateral hand/arm movements (i.e., affect-to-action link) rather than on the influence of hand movements on affect (i.e., action-to-affect link) as, for instance, the above-described study by Hayes et al. (2008) indicated with the influence of lateral actions with objects on the valence appraisals toward the objects. Therefore, this leaves open the question as to whether the positive or negative affective connotation of the non-/dominant hand or lateral arm movements may have an influence on the subjects' affectivity. Moreover, it is quite unclear what to expect when actions of the non-/dominant hand are more naturally performed in direct contact with an affective object or when lateral movements of the hands integrate both the dominant and the non-dominant spaces (cf. Casasanto, 2009; Hayes et al., 2008; see Table 1).

Table 1. Righthanders' associations between the valence category of stimuli (in parenthesis) and: a) lateral space (left / right), b) hand dominance (left / right) and c) lateral movements to the right or to the left.

| | Lateral space | Hand dominance | Lateral movement | Measure |
|---|---|---|---|---|
| BSH Casasanto (2009) | Right (+)<br>Left (-) | | | Judgments' Ratios |
| De la Vega et al. (2012) | Right (+)<br>Left (-) | | | Response Time |
| de la Vega et al. (2013) | | Right hand (+)<br>Left hand (-) | | Response Time |
| Milhau et al., (2014) | | | Right hand rightwards ➔ (+)<br>Left hand leftwards 🡐 (+) | Response Time |

## 3.3. Valence associations with the vertical space: metaphorical mappings

The valence associations with the vertical space have been shown to adopt the metaphorical mapping: positive valence is "up" and negative valence is "down" (e.g., Crawford, 2009). In this case, metaphorical expressions such as "feeling up" or "feeling down" play an important role to indicate affective states such as happiness or sadness (e.g., Meier & Robinson, 2005). According to the Conceptual Metaphor Theory (Lakoff & Johnson, 1980), this valence-space metaphor structure is grounded in sensorimotor experiences stemming from systematic bodily expressions of emotion, which manifest in the vertical dimension of space. Moreover, in contrast to the horizontal space, such associations may not depend on dominant bodily components (cf. Damjanovic & Santiago, 2015). In line with this notion, embodiment literature has shown that bodily experiences may influence affective responses in line with this valence–space metaphor. For example, upright postures may positively influence the evaluation of presented stimuli (e.g., funny cartoons) because these postures are often associated with positive affect compared to slumped postures, which are associated with negative affect (e.g., Nair, Sagar, Sollers, Consedine, & Broadbent, 2015; Stepper & Strack, 1993). In a similar way, performing vertical head movements (i.e., nodding), which are usually associated with affirmative responses, have been found to influence the recovery of negative mood states compared to performing lateral head movements (i.e., shaking), which are usually associated with negative responses (Rahona, Ruiz-Fernández, Rolke, Vázquez, & Hervás, 2014). Furthermore, a great body of experimental research has supported this association between valence and vertical space. In particular, it has been examined how valence-laden information (e.g., affective concepts) may activate mental representations of vertical space, which has been measured by means of hand or arm responses. Meier and Robinson (2004) showed that participants judged the valence of positive words faster (e.g., baby), when they were presented at the top (vs. bottom) area of a monitor screen. The opposite held for negative words (e.g., "foolish") with faster evaluations when the words were presented in the bottom area (vs. top; see Figure 10). This suggested that processing positive and negative valence was highly associated with the vertical spatial locations. Specifically, congruent affective matchings (i.e. positive-up and negative-down) resulted in shorter response latencies, whereas incongruent matchings (i.e., positive-down and negative-up) resulted in longer response latencies.

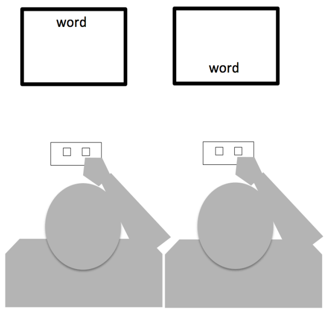


*Figure 10*. Depiction of an experimental setting with subjects responding to valence-laden words displayed at the top or bottom areas of a monitor-screen (cf. Meier & Robinson, 2004).

Interestingly, the processing of valence-laden stimuli has also been associated with the performance of vertical arm movements. For example, Dudschig, de la Vega, and Kaup (2015; see also Brookshire, Casasanto & Ivry, 2010) asked participants to judge the valence of words presented in the center of a monitor screen. Specifically, participants had to release a key from the center of a vertically mounted keyboard and press a key on the upper side or a key on the lower side of the keyboard (see Figure 11). Therefore they performed upward or downward arm movements. The findings indicated that participants performed upwards movements faster subsequent to the presentation of positive stimuli. In contrast, they performed downward movements faster subsequently to the presentation of negative stimuli.

These findings suggested that the processing of affective stimuli facilitated the performance of arm movement responses compatible with the congruent affective matching (i.e., positive – upward; negative – downward) but on the contrary, hindered arm movement responses with the affective mismatching (i.e., positive – downwards; negative – upwards).

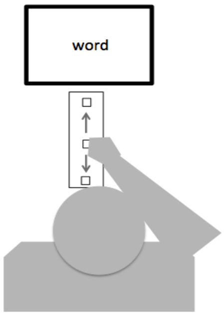


*Figure 11*. Depiction of an experimental setting where subjects judge the valence of a stimulus by means of upward or downward arm movements (cf. Brookshire, et al., 2010; de la Vega et al., 2015).

In summary, according the just described studies one may argue that research in this field focused on two main aspects. The first addressed the processing of affective concepts located in vertical spaces, and the second addressed the performance of vertical arm movements (upward/downward) as related with the processing of affective stimuli.

Nevertheless, for the issues addressed in the present dissertation, the study by Sasaki, Yamada and Miura (2015) is of special relevance. In this study, the authors used a touchscreen monitor to examine the influence of the affective connotations attributed to upwards and downwards arm movements (i.e., upward – positive; downward – negative) on valence appraisals towards emotional stimuli (i.e., action-to-affect link). Interestingly, rather than words, participants were presented with positive and negative emotional pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997) on the touchscreen. Specifically, the pictures were displayed for 500ms at the center of the screen and disappeared after this time. Then a dot appeared instead, together with an action cue indicating whether the dot had to be touched and moved towards an upper or to a lower location of the screen, hence, performing an upward or downward arm movement. After moving the dot to the indicated location, participants rated the valence of the pictures on a numerical scale. The crucial finding was that the valence of the pictures was on average more positive following upward arm movements and more negative following downward arm movements. The authors explained this arm movement effect with the valence–space metaphor mapping suggesting that an upward arm movement was associated with positive valence and a downward arm movement with negative valence. Moreover, they concluded that the valence associated with the movement retrospectively modulated the valence appraisals towards the presented emotional pictures.

In line with the focus of the present dissertation, which is to examine the influence of touchscreen interactions on users' affectivity, the study by Sasaki et al. gathers three important elements: a) the use of a touchscreen environment, b) the integration of emotional pictures with the interface, and c) it focuses on the influence of vertical arm movements on the participants' affectivity as reflected by their appraisals towards the pictures (i.e., action-to-affect link). However, although these elements are highly relevant, it is rather difficult to derive from that study useful implications in line with a positive technology perspective. To put things simply, the participants did not use their hands to interact with the pictures, as it is rather standard when using touchscreen interfaces. Indeed, this could be a strong point considering findings on embodied interaction and near-hand effect described in chapter 2. Those findings suggested that interacting with digital pictures directly with the hand may enhance their visuospatial processing. Therefore, at this point, it would be quite necessary to examine whether using the hand to directly interact with emotional pictures in a vertical touchscreen space would lead to different effects that than the ones reported in the study by Sasaki and colleagues. Table 2 summarizes the most relevant findings stemming from the above-described research.

Table 2. Associations between the stimuli' valence category (in parenthesis) and: a) vertical space (up / down), and b) vertical arm movements (upward / downward). Note: in Sasaki et al. (2015) valence (in parenthesis) represents the affective connotation of the movement.

| | Vertical space | Vertical movement | Measure |
|---|---|---|---|
| Meier & Robinson (2004) | Up (+)<br>Down (-) | | Response Time |
| De la Vega et al. (2015)<br>Brookshire et al. (2010) | | Upward 🡩 (+)<br>Downward 🡫 (-) | Response Time |
| Sasaki et al. (2015) | | Upward 🡩 (+)<br>Downward 🡫 (-) | Valence appraisals |

## 3.4. Valence associations with the sagittal space: approach – avoidance

Finally, metaphorical expressions such as "they are close friends" or "you look distant lately" might indicate mental representations of affective experiences grounded in the physical distance (e.g., closeness – positive; distance – negative; see Trope & Lieberman, 2010, for a review). Interestingly, at a behavioral level, the associations between emotional valence and sagittal space (i.e., front/back) have been framed in the so-called approach and avoidance motor tendencies. This is usually understood as the tendency to approach positive stimuli but to avoid negative stimuli (e.g., Lang & Bradley, 2010; Neumann, Förster, & Strack, 2003). Many situations, for instance, require making decisions about whether to approach or avoid an object or a person, thus, involving cognitive and affective processes (e.g., Elliot, Eder, & Harmon-Jones, 2013). Although the cognitive mechanisms are still under debate (e.g., Kozlik, Neumann, & Lozo, 2015), there is relative agreement on defining approach behaviours in terms of reducing the distance between two elements, and avoidance behaviors in terms of increasing the distance between them (i.e., distance regulation; Van Dantzig, Pecher & Zwaan, 2008; Strack & Deutsch, 2004). Along with this line of reasoning, a great body of experimental research has been provided demonstrating compatibility effects between the processing of valence-laden stimuli and the performance of subsequent motor responses (i.e., affect-to-action link; see Phaf, Mohr, Rotteveel, & Wicherts, 2014 for a review). These effects will be explained as follows: the procedure of the studies investigating these effects usually consists of presenting positive or negative stimuli on a monitor-screen (e.g., words) and instructing participants to judge their valence by means of backward or forward arm movements (see Markman & Brendl, 2005; Dantzig, Zeelenberg, & Pecher, 2009 for alternative procedures). Nevertheless, forward and backward arm movements may convey different meanings depending on the frame of reference of a situation or a task, namely, when the self is the reference or when an object is the reference (e.g., Seibt, Neuman, Nussinson, & Strack, 2007). For example, from a self-reference frame, backward arm movements (e.g., pulling a lever) would represent "approaching" actions, which decrease the distance between the self and an object, and are faster when processing positive stimuli (i.e., backward – positive). In contrast, forward arm movements (e.g., pushing a lever) would represent "avoiding" actions, which increase the distance between the self and an object, thus, being faster when processing negative stimuli (i.e., forward – negative; Chen & Bargh, 1999). Conversely, from an object-reference frame backward arm movements would represent "withdrawing" actions, which increase the distance between the object and the self, hence, being faster when processing negative stimuli (i.e., backward – negative). In contrast, forward movements would represent "reaching" actions, which decrease the distance between the object and the self, hence, being faster when processing positive stimuli (i.e., forward – positive; Saraiva, Schüür, & Bestmann, 2013). Therefore, backwards and forward arm movements may be both, positively or negatively connoted depending on whether the frame of reference is the self or an object.

Interestingly, there is an additional aspect of these two reference frames with strong relevance from an embodied touchscreen interaction perspective. That is, they could be differently activated depending on whether a subject manipulates an object with the hands. The study by Freina, Baroni, Borghi and Nicoletti (2009) demonstrated this effect. Participants had to judge the valence of positive on negative words presented in a monitor screen. To do so, they performed backwards or forward arm movements on a lengthwise positioned keyboard, hence, with the narrow edge facing the subjects. Specifically, the keyboard showed two buttons, one at the distal ("far") location from the participants' position and the other at the proximal ("close") location from their position. In order to make their judgments participants released first the responding hand from a middle centered key on the keyboard and then pressed one of the buttons. In addition, one group of participants responded without carrying an object with the hand (i.e., bare–hand condition) whereas a different group responded while carrying a tennis ball with their hand (i.e., full-hand condition).

The crucial finding was that participants in the bare-hand condition exhibited compatibility effects typical of the object-reference frame. Therefore, positive stimuli led to faster forward "reaching" responses towards the distal button (i.e., positive - distal) compared to the proximal button, whereas negative stimuli led to faster backward "withdrawal" responses towards the proximal button (i.e., negative - proximal) compared to the distal one. In contrast, subjects in the full-hand condition exhibited compatibility effects of the self-reference frame. Accordingly, this time positive stimuli led to faster backward "approaching" responses towards the proximal button (i.e., positive – proximal), whereas, negative stimuli led to faster forward "avoidance" responses towards the distal button (i.e., negative – far). This effect suggested the activation of a self-reference frame. Therefore, the activation of an object- or a self-reference frame was sensitive to the hand postures, in this case carrying an object or not.

From a technology perspective, the idea that manipulating an object activates the self-reference frame has been recently supported when interacting with emotional pictures on a touchscreen device. Krauss and Hoffmann (in Krauss, 2014; see also Bamford & Ward, 2008) presented what they termed as the Swipe Approach-Avoidance Procedure (i.e., SwAAP). According to the SwAAP, participants had to first touch positive or negative emotional IAPS pictures at an initial starting center point of the touchscreen. Then, to swipe the pictures backwards to a neutral target located at the proximal edge of the device (i.e., closer to the participant's position) or forwards to the distal edge (i.e., further from the participant's position). The crucial finding was that participants moved the positive pictures backwards faster compared to the negative pictures. In addition, participants tended to move the negative pictures faster forward compared to backwards. In other words, interacting directly with emotional pictures on the touchscreen partially supported the compatibility effects falling in a self-reference frame.

Indeed, this study represented an initial connection between embodied cognition and embodied interaction accounts with regard to the sudy of affect and its relationship with the sagittal space. More importantly, the study reinforces also the notion that swipe gestures performed in the sagittal space are good candidates to influence users' affectivity. However, this aspect has not been examined yet in a comparable paradigm, namely, in a touchscreen environment. This is quite surprising considering that experimental research on approach-avoidance has also provided numerous examples of how bodily activity influence affect (i.e., action-to-affect link; see Price, Peterson & Harmon-Jones, 2012 for a review).

In this regard, previous research has reported that holding flexion arm positions (i.e., by pressing a hand's palm against the bottom of a surface) is associated with approach (positive) behaviours. In contrast, holding extension arm positions (i.e., by pressing the hands' palm against the top of the surface; see Figure 12) are associated with avoidance (negative) behaviours (e.g., Cacioppo, Prierster & Berston, 1993). In line with this notion Centerbar and Clore (2006) reported compatibility effects related to valence appraisals towards affective stimuli.

Based on pre-ratings of Chinese ideographs, the authors differentiated between positive and negative stimuli' valence categories. In the experimental task the stimuli were presented on a computer screen. Then, two groups of participants reported valence' appraisal towards the stimuli on a numerical scale while holding either an arm flexion position or an arm extension position. The results showed that when the arm positions matched the valence of the stimuli (i.e., arm flexion-positive; arm extension-negative), the valence appraisals were more positive (i.e., positive stimuli evaluated as more positive and negative stimuli evaluated as *less* negative). Conversely, when the movements mismatched the valence of the stimuli (i.e., arm flexion – negative; arm extension – positive), the valence evaluations were more negative (i.e., positive stimuli evaluated as *less* positive and negative stimuli evaluated as more negative). The authors concluded that the arm positions influenced the valence appraisals towards the stimuli, but also that the direction of this influence depended on the stimuli' valence category, which share parallels with the compatibility effects found in the affect-to-action link (see Dru & Cretenet, 2008 for similar results with emotional pictures).

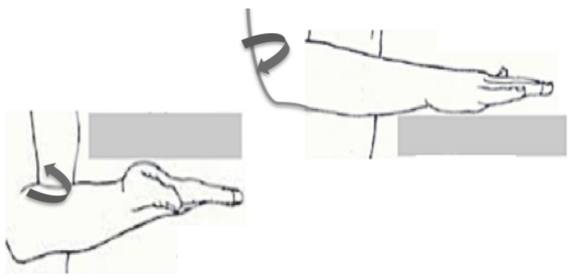

*Figure 12*. Depiction of an approach-avoidance experimental setting within the action-to-affect link. Left part: flexion arm position involving the tension of biceps. Right part: extension arm position involving the tension of triceps (cf. Cacioppo et al., 1993).

In summary, approach-avoidance experimental paradigms requiring the performance of arm movements (i.e., forward/backward or flexion/extension) revealed compatibility effects in both, the affect-to-action link and the action-to-affect link. Accordingly, positive stimuli are typically associated with approach-like arm movements whereas negative stimuli are associated with avoidance-like arm movements. In line with this notion, some evidence has been provided that embodied touchscreen interactions (e.g., forward or backward swipe gestures) with valence-laden contents (e.g., emotional pictures) lead to similar compatibility effects of those in the affect-to-action link (e.g., Kraus et al., 2014). However, it cannot be concluded whether performing such interactions may indeed influence users' affectivity (e.g., valence appraisals; Centerbar & Clore, 2006). Accordingly, this is an aspect that requires further examination. Moreover, there is an additional finding that deserves special mention. A recent study suggests that displaying valence-laden stimuli on a touchscreen device at a proximal ("close") or distal ("far") location with regard to a subject' position, influences the visuospatial processing of the stimuli. In general, displaying affective stimuli at proximal (vs. distal) location reflected motor brain activity associated with reaching "touch" actions even when participants were not asked to touch the stimuli. This suggested a higher visuospatial processing of the stimuli displayed "closer" to the participants' positions. Interestingly, exploration in for detail indicated that negative stimuli were processed faster at distal locations compared to positive stimuli, suggesting a distal negative connotation compared to a potential proximal *positive* connotation (Valdés-Conroy, Sebastián, Hinojosa, Román, & Santaniello, 2014). In conclusion, it seems that manipulating valence-laden contents in a touchscreen environment may enforce a self-reference frame, and in addition, the visuospatial processing of the stimuli is sensitive to its proximal or distal location (see Table 3).

Table 3. Associations (from self-reference frame) between the valence category of stimuli (in parenthesis) and: a) arm positions (flexion-approach; extension-avoidance), and b) directional movements (backwards-approach / forward-avoidance).

| | Sagittal movement | Measure |
|---|---|---|
| Cacioppo et al. (1993);<br>Certerbar & Clore (2006) | Extension (-)<br>Flexion (+) | Valence appraisals |
| Chen & Bargh (1999); Freina et al. (2009);<br>Kraus et al. (2014) | Forward ⇖ (-)<br>Backward ⇘ (+) | Response Time |

## 3.5. From valence-space associations to embodied touchscreen interactions

Up to this point, the reader may conclude that experimental research framed in embodied cognition accounts has provided a quite extensive body of findings related to valence – space associations and directional arm movements or arm positions. Concretely, the research described so far reports on motor compatibility effects in three bodily dimensions of space (i.e., horizontal, vertical and sagittal). These compatibility effects are explained considering embodied approaches to emotion, which suggest a bidirectional link between affect and bodily activity:  valence-laden information stimulates motor responses (e.g., response times; affect-to-action link), and motor activity influence affective responses (e.g., valence appraisals; action-to-affect link). Furthermore, congruent affective matchings between presented valence–laden information and bodily activity may result in faster motor responses or more positive appraisals. In contrast, affective mismatchings result in slower responses or more negative appraisals (e.g., Centerbar & Clore, 2006; Clore & Schnall, 2008; Niedenthal, 2007).

Nevertheless, only a few studies have investigated such effects in line with an embodied touchscreen interaction perspective. For instance, the SwAAP (Swipe Approach-Avoidance Procedure; Krauss et al., 2014) where subjects manipulated emotional IAPS pictures in a touchscreen, to examine their motor responses, could be considered as a good example falling in the affect-to-action link. Indeed research on embodied touchscreen interaction (see Chapter 2) reinforces the idea that swipe interaction gestures might be good candidates to inspect the processing of valence-laden contents and, thereby its potential influence on affect. The reason for why that might be is because, a) swiping images may convey meanings such as moving a physical real object, thus, highlighting their spatial representation on the screen (e.g., Kranz et al., 2012) and in addition, b) the direct hand interaction with the content when performing swipe gestures may stimulate their visuospatial processing (e.g., Brucke et al., 2016). However, so far, it is still unclear whether interacting valence-laden contents such as emotional pictures by means of directional swipe gestures might, in fact, influence user's affectivity.

In this regard, one last aspect to mention, though not less relevant, is that an important number of studies have used emotional IAPS pictures as stimuli. These pictures are rich in valence-laden contents with greater or lesser intensity and are often used in studies investigating the affect-to-action link, hence, stimulating affect first and then examining a motor response (e.g., Dai et al., 2016). Interestingly, valence appraisals towards these pictures have also been connected to cognitive appraisals, such as the ones concerning to personal dimensions of well-being (e.g., evaluations related to needs, goals, and values; Scherer, Dan, & Flykt, 2006). This is highly important in positive technology research, which often integrates these sorts of materials in virtual environments and interactive interfaces to investigate and promote the quality of users' affective experiences (Baños et al., 2012).

Therefore, along this line of reasoning, the thesis presented here proposes to approach the applied view of embodied touchscreen interaction research to the experimental studies reporting valence-space associations with related directional arm movements. To put things more concretely, this thesis aims to investigate if or how interacting with emotional pictures by means of directional swipe gestures may influence user's affectivity. The potential findings of the studies conducted here could shed new light on the consideration of touchscreen interfaces as "positive technologies" from an embodied perspective. Accordingly, the next chapter will present three experimental studies examining touchscreen interactions with positive and negative emotional pictures by means of horizontal (Study 1), vertical (Study 2) and sagittal (Study 3) swipe gestures.

# 4. Research Questions

The goal of the present dissertation was to investigate, from an embodied perspective, the potential of touchscreen interfaces as positive technologies. Accordingly, it was examined if and how interacting with emotional pictures on a touchscreen space by means of directional swipe gestures, would influence the subjects' affectivity as reflected in their valence appraisals towards the pictures. Specifically, building upon the Body Specificity Hypothesis (BSH; Casasanto, 2009) Study 1 will examine the subjects' interactions with emotional pictures by means of swipe gestures in a horizontal touchscreen space. In contrast, Study 2 will be framed in metaphorical valence-space mappings and will examine swipe gestures in a vertical touchscreen space. Finally, in line with approach-avoidance motor tendencies, Study 3 will examine swipe gestures in a sagittal touchscreen space.

Against the backdrop of the theoretical and experimental considerations presented in preceding sections, two main research questions were considered:

RQ1. Are directional swipe gestures useful to influence subjects' affectivity?

RQ2. May embodied touchscreen interactions (i.e., swiping) reflect valence–space (mis) matchings similar to those reported in embodiment literature?

In the following, three different studies will be reported in order to shed light on these questions.

# Study 1: Swiping emotional pictures in a horizontal touchscreen space

The goal of the present study was to investigate whether interactions with emotional pictures by means of swipe gestures on a horizontal touchscreen space (i.e., rightwards or leftwards) would influence subjects' appraisals towards the pictures. The study builds upon findings from the Body Specificity Hypothesis as a theoretical framework and related experimental research (BSH; Casasanto, 2009). The BSH suggests that for right-handers, the space surrounding the dominant right hand (i.e., dominant right space) is associated with positive valence whereas the space surrounding the non-dominant left hand (i.e., non-dominant left space) is associated with negative valence (i.e., right space – positive; left space – negative). Further studies based on the BSH also reported:

a) Affective connotations of the non-/dominant hands (i.e., dominant right hand – positive and non-dominant left hand – negative; de la Vega et al., 2013); or in contrast,
b) Affective connotations of lateral movements of the hands regardless hand dominance (i.e., right hand to the right space (rightwards) – positive; left hand to the left space (leftwards) – positive; Milhau et al., 2014).

The first concern of Study 1 was to integrate those affective dimensions in a touchscreen environment (i.e., lateral space, non-/dominant hand, and lateral movement) joint to the valence-laden pictures. Accordingly, an experimental touchscreen setting was designed where subjects had to swipe emotional pictures from the right to the left sides on the touchscreen, thus, requiring leftward arm movements, or from the left to the right sides, thus, requiring rightward arm movements (see Hayes et al., 2008 for similar movements in a non-touchscreen setting). In addition, half of the participants manipulated the pictures with their dominant right hand whereas the other half used their non-dominant left hand.

The second and most important concern of the study was to examine the potential affective influence of those manipulations on the subjects' valence appraisals towards the pictures. Specifically, these appraisals consisted in valence' ratings of the pictures on a numerical scale. However, manipulating pictures with the dominant or non-dominant hand by means of lateral movements could create a potential conflict between the affective influence of these two bodily dimensions, namely, one according to hand dominance and one according to the lateral arm movements. Against this backdrop, the following hypotheses were formulated.

## 5.1. Hypotheses

H.1. If hand dominance is the only bodily aspect influencing subject's appraisals towards the pictures, an interaction between hand and picture' valence category is expected, regardless of the lateral movements (i.e., hand dominance – hypothesis; cf. de la Vega et al., 2013).

H.2. If lateral swipe gestures to the right or to the left (and not only hand dominance) influence the subjects' appraisals towards the pictures, an interaction between hand, lateral movement and picture' valence category is expected (i.e., hand and movement – hypothesis).

## 5.2. Method

### *5.2.1. Participants*

A total of 120 right-handed participants ($M_{\text{age}}$ = 25.2, *SD* = 7.6; 78.3% women) took part in the experiment in exchange for monetary reward. Informed consent was signed prior the participation in the study. Handedness was tested with the German translation of the Edinburgh Inventory (Oldfield, 1971) modified by Salmaso and Longoni (1986).

*5.2.2. Apparatus and stimuli*

A large scaled touchscreen monitor (TM; Dell™-Monitor S2340T) connected to a computer (Lenovo ThinkPad T410, Intel Core i7 620M, 2.67 GHz) was used to display the stimuli. The TM was of 23 inch (20.99" (V) x 12.28" (H) Activ-Matrix-TFT-LCD and featured a resolution of 1600 x 900 pixels. Forty pictures from the International Affective Picture System[1] (IAPS; Lang, Bradley, & Cuthbert, 1997) were used as stimuli. According to the IAPS' valence ratings, twenty pictures were positive (e.g., animals and families) and twenty negative (e.g., aggressive faces), with neutral arousal on average. An ANOVA on the pictures' valence means confirmed differences between the valence categories ($M_{positive}$ = 7.22, $SD_{positive}$ = .53; $M_{negative}$ = 2.77, $SD_{negative}$ = .53), $F(1, 38) = 595$, $p < 0.001$. Pictures' arousal means, on the contrary, did not show significant differences ($M_{positive}$ = 4.86, $SD_{positive}$ = .39; $M_{negative}$ = 5.03, $SD_{negative}$ = .49), $F(1,38) = 1.46$, $p = 0.15$. Pictures were presented on the TM with a resolution of 397 x 340 pixels (10.5 cm x 9 cm), at a distance of 42 cm to an empty square (6.2 cm x 6.2 cm).

*5.2.3. Procedure and design*

In order to control for the differences within and between the experimental groups, participants rated the valence of the pictures 48 hours prior to the experiment. In the experimental task, participants were randomly assigned to one of four experimental groups. Two groups of participants touched and subsequently moved the pictures with their dominant right hand: one group moved the pictures from the right side of the TM to the left side (i.e.,

[1]The following pictures were used as stimuli: positive: 1340, 1811, 1920, 1999, 2154, 2209, 2311, 2340, 2346, 2352, 2362, 2373, 2391, 2398, 2550, 2900.2, 4250, 4520, 5628, 8500; negative: 1111, 1270, 1274, 2120, 2141, 2205, 2375, 2692, 2710, 2800, 3350, 6242, 9000, 9090, 9280, 9342, 9417, 9440, 9560, 9911.

leftwards) where an empty square indicated the movement end point; the other group, moved the pictures from the left side of the TM to the right side (i.e., rightwards). Two further groups of participants performed similar movements; this time using their non-dominant left hand (see Figure 13). After each movement, the just moved picture was presented again in the middle of the TM together with a Likert scale below it, in order to rate its valence. Here participants had to rate the picture using numbers between 1 (low valence) and 9 (high valence). Immediately after this appraisal the next picture was presented. The order of all pictures was randomized. Therefore, the factors hand (right vs. left) and movement (rightwards vs. leftwards) were manipulated between participants, whereas the factor valence category (positive vs. negative) was manipulated within participants.

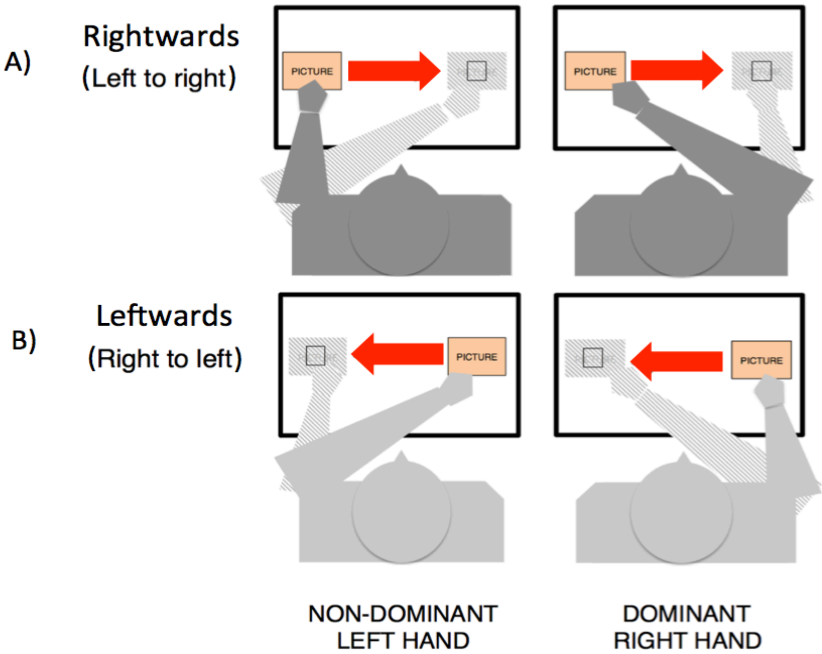


*Figure 13*. Depiction of the experimental setting in Study 1: A) Two groups of participants (n=30 each) swiping emotional pictures with the dominant right hand, one group rightwards (i.e., left-to-right) and the other leftwards (i.e., right-to-left). B) Two further groups of participants (n =30 each) swiping emotional pictures with the non-dominant left hand, on group rightwards (i.e., left-to-right) and the other leftwards (i.e., right-to-left). Shaded gray areas represent the final position of arms and pictures.

## 5.3. Data analyses and results

All analyses were performed by means of linear mixed-effects models (LMM) via maximum likelihood (ML) with the software package SPSS 21.0 (IBM). This method has been found appropriated to simultaneously control the error variance with regard to subjects, stimuli and/or subject x stimuli interactions (e.g., Baayen, Davidson, & Bates, 2008; Barr, Levy, Scheepers, & Tily, 2013). Valence ratings greater or less than 3SDs of each subject average in the positive and negative pictures' categories and of each picture average in each experimental group were excluded from further analyses (2%). The modelling of the resulting data reached better goodness of fit ($AIC$ = 14430.8)[2] compared to a random-factor-only model, ($AIC$ = 16337.3), $\chi^2 = 20.09$, $p < 0.01$. To calculate $p$ values estimates for the fixed-effects, it was used a Type III Satterthwaite approximation (e.g., Carr, Rotteveel, & Winkielman, 2016; West, Welch, & Galecki, 2014).

Valence ratings were analyzed by means of linear mixed model (LMM) with a 2 (Hand: right vs. left) x 2 (Movement: rightward vs. leftward) x 2 (Valence category: positive vs. negative), fixed factor structure. Hand and movement were manipulated between subjects whereas valence category was manipulated within subjects. Valence ratings of the baseline were used as a control covariate. Subjects and pictures were included as random factors with random intercepts in order to account for between-subjects and between-pictures differences on the valence evaluations.

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[2] Akaikes' Information Criterion (AIC) is an indicator of the relative quality of statistical models interpreted as smaller is better form. It takes into account the model accuracy in terms o the explained variance and the model complexity in terms of the number of predictors included.

The analyses showed a significant main effect of hand $F(1,117) = 7.9$, $p = 0.006$, indicating that the pictures' ratings were more positive after swiping them with the right hand than after swiping them with the left hand. The main factor movement showed also significant effects, $F(1,117) = 5.4$, $p = 0.022$, indicating that leftwards (right-to-left) movements lead to more positive pictures' ratings than rightwards (left-to-right) movements. Not surprisingly, the factor valence category was significant, $F(1,68) = 451.5$, $p < 0.001$, indicating that positive pictures were more positive rated than negative pictures. The two way interactions between hand x movement ($F(1,117) = 1.7$, $p = 0.19$), hand x valence category ($F(1,4529) = 1.3$, $p = 0.24$), and movement x valence category ($F(1,4531) = .17$, $p = 0.67$) did not show significant effects. Interestingly, the significant main effects were qualified by the highly significant three way interaction between hand, movement and valence category, $F(1,4529) = 10.7$, $p = 0.001$ (see Figure 14).

To give further insight on this interaction, post-hoc analyses (using Bonferroni correction) will be described for each hand:

a) Dominant right hand

Swiping positive pictures with the right hand resulted in more positive ratings after leftwards (right-to-left) than after rightwards movements (left-to-right), $t(241) = 1.99$, $p = 0.047$, $d = .26$. In contrast, swiping negative pictures with the right hand did not show significant differences between rightwards (left-to-right) and leftwards (right-to-left) movements, $t(218) = .81$, $p = 0.42$.

b) Non-dominant left hand

Swiping positive pictures with the left hand did not show significant differences on the pictures' ratings between rightwards (left-to-right) and leftwards (right-to-left) movements,

$t(238) = 1.1$, $p = 0.23$. Interestingly, swiping negative pictures with the left hand rightwards (left-to-right) resulted in more negative ratings than swiping the pictures leftwards (right-to-left), $t(217) = -3.3$, $p = 0.001$, $d = .73$

In addition to these results, swiping positive pictures leftwards (right-to-left) with the right hand resulted in more positive ratings than using the left hand, $t(240) = 2.6$, $p = 0.010$, $d = .43$. Moreoever, swiping negative pictures rightwards (left-to-right) with the left hand resulted in more negative ratings that using the right hand, $t(218) = -3.3$, $p = 0.001$, $d = .73$

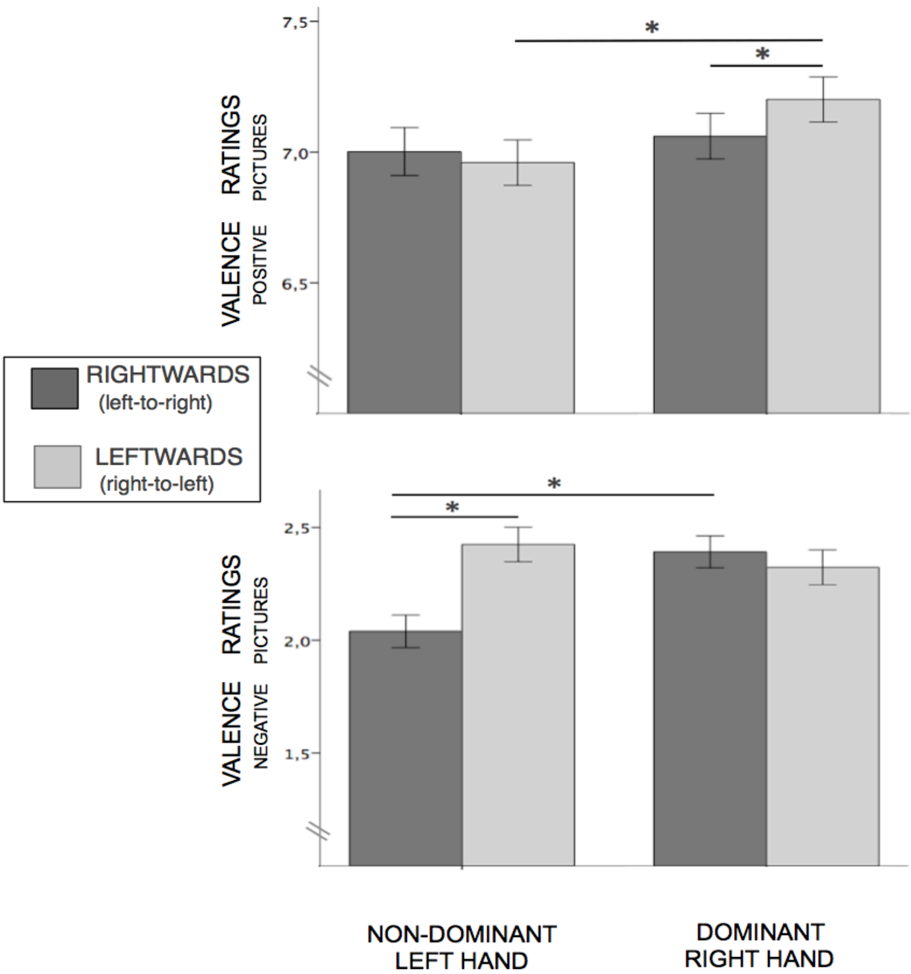


*Figure 14*. Valence ratings of positive and negative pictures after lateral movements of the dominant right hand (right part) or the non-dominant left hand (left part) *$p$<0.05 (error bars represent 95% confident intervals).

## 5.4. Discussion

Study 1 examined whether swiping emotional pictures on a horizontal touchscreen monitor space, either with the dominant right hand or the non-dominant left hand, would influence participants' affectivity as reflected in their valence' appraisals towards the pictures (i.e., numerical ratings). To do so, right-handed participants touched and subsequently moved the pictures with, a) their dominant right or their non-dominant left hand, and b) either leftwards (i.e., from the right to the left space) or rightwards (i.e., from the left to the right space) on the touchscreen. Two mechanisms were examined as a potential influence on the pictures' valence ratings. On the one side, if only hand dominance would influence the valence ratings of the pictures, an interaction between hand and valence category was expected (hand dominance – hypothesis). On the other side, if lateral movements and not only hand dominance would influence the ratings, an interaction between hand (right or left), lateral movement (right-to-left or left-to-right) and valence category (positive or negative) was expected (hand and movement – hypothesis). The result-pattern of the present study supports the hand and movement – hypothesis. Concretely, the results showed that swiping positive pictures with the dominant right hand leftwards (from right-to-left spaces on the touchscreen) resulted in more positive pictures' ratings, whereas swiping negative pictures with the non-dominant left hand rightwards (from left-to-right spaces on the touchscreen) resulted in more negative ratings. The first and more striking observation in this pattern of results is that apparently the effects emerged when the hands performed an "incongruent" lateral movement (i.e., right hand moving leftwards; left hand moving rightwards).

A possible explanation for this pattern follows the subsequent rationale. Former studies suggest that, for righthanders, there exist different matching possibilities between the valences of 1) the interacting hand (right hand – positive / left hand – negative; de la Vega et al., 2013), 2) the picture' valence category (i.e., positive or negative), and 3) the space surrounding the hands (right space – positive / left space – negative; cf. Casasanto, 2009), which is at the same time the point from where the subjects move the pictures (i.e., movement' starting point). Hence, the valences of the three factors or the valence of two of them can match (see Table 4).

Table 4. Influence on valence appraisals (ratings) stemming from the match between the valence (in parenthesis) associated with: a) Hand, b) pictures' valence category, and c) movement' starting point (lateral).

| *Hand* | *Valence category* | *Movement' starting point* | *Valence' match* | *Influence on valence appraisals (ratings)* |
|---|---|---|---|---|
| Dominant Right (+) | Positive (+) | ←Right (+) | 3xMatch | More positive (R) |
| | | Left (-) → | 2xMatch | Less positive (A) |
| | Negative (-) | ←Right (+) | | n.s. |
| | | Left (-) → | | n.s. |
| Non-dominant Left (-) | Positive (+) | ←Right (+) | | n.s. |
| | | Left (-) → | | n.s. |
| | Negative (-) | ←Right (+) | 2xMatch | Less negative (A) |
| | | Left (-) → | 3xMatch | More negative (R) |

Note: n.s. (non-significant); (R) Reinforcement; (A) Attenuation

The results of the present study, as represented in the table suggest that: 1) using the hand that matches to the picture' valence category (i.e., *"positive"* dominant right hand - *positive* pictures and *"negative"* non-dominant left hand - *negative* pictures), and 2) starting the movement from the space that matches the hand (i.e., *positive* dominant hand – *positive* right dominant space and *negative* non-dominant hand – *negative* left non-dominant space) lead to a *"reinforcement"* of the pictures' valence category. In other words, *negative* pictures were rated more *negative*ly and *positive* pictures more *positively*. Accordingly, the subjects rated the pictures as more positive only if they moved them, 1) with the hand that matches the pictures' valence category (i.e., *"positive"* dominant right hand - *positive* pictures and *"negative"* non-dominant left hand - *negative* pictures), and 2) starting from participants' *"positive"* dominant right space. Which is indeed is in line with the Body Specificity Hypothesis (Casasanto, 2009).

Therefore, these findings suggest that swiping emotional pictures in a touchscreen environment may be useful to influence subjects' affectivity as reflected in their appraisals towards the pictures (see RQ1). On the other side, it appeared that the effects showed compatibility effects in terms of valence' matches including not only the dominant right or non-dominant left hands but also lateral movements (see RQ2). Nevertheless, in light of the results it seems that the affective influence of the lateral movements relies on the movement' starting point. This is an aspect that will be expanded upon in the general discussion.

## Study 2: Swiping emotional pictures in a vertical touchscreen space

The goal of the present study was to investigate whether manipulating emotional pictures by means of swipe gestures on a vertical touchscreen space (i.e., upwards or downwards) would influence subjects' appraisals towards the pictures. This study builds upon former findings indicating that performing vertical arm movements on a touchscreen monitor influenced subjects' valence appraisals towards emotional pictures (Sasaki et al., 2015). Specifically, participants reported on average, more positive evaluations of the pictures after performing upward arm movements. In contrast, they reported more negative evaluations after performing downward arm movements. These effects supported the affective connotation of the movements (i.e., upward – positive and downward – negative), in line with the Conceptual Metaphor Theory (Lakoff & Johnson, 1980; see section 3.3 in Chapter 3). However, this study used a touchscreen interface, but participants did not interact with the pictures, something that is rather standard in touchscreen environments. Indeed, considering that previous findings show that interacting pictures directly with the hand may influence their visuospatial processing, direct interactions with emotional pictures on the touchscreen, could result in critical differences with regard to the finding reported by Sasaki and colleagues (e.g., Brucker, et al., 2017; cf., Reed, et al., 2006). Moreover, considering that up or down vertical spaces have been found to also be affectively connoted (i.e., up – positive and down – negative; Meier & Robinson, 2004), the present study examined whether subjects using their hand to directly interact with emotional pictures on the touchscreen, downwards (from the top to the bottom) or upwards (from the bottom to the top) would influence their valence appraisals towards the pictures.

Accordingly, the following hypotheses were derived:

## 6.1. Hypotheses

H.1. If touching the pictures during performing the vertical swipe moving gesture is irrelevant for influencing subject's appraisals towards the pictures, a similar main effect of vertical movement was expected as in the study by Sasaki et al. (2015). Accordingly, the moving direction of the pictures should influence their evaluation regardless of their valence (*moving direction hypothesis*). This means that both, positive and negative pictures should be evaluated more positively after moving them upwards on the touchscreen (i.e. bottom-to-top) and more negatively after moving them downwards (top-to-bottom). However:

H2. If touching the pictures during performing the swipe moving gesture is indeed relevant to influence subject's appraisals of the pictures, a different outcome is expected (*touch hypothesis*). In this case the valence category of the picture (i.e. positive or negative) that sticks to the interacting hand could be into the focus of attention together with the valence associated with the surrounding space (i.e. top or bottom; near-hand effect; cf. Brucker et al., 2017).

## 6.2. Method

### *6.2.1. Participants*

A total of 60 right-handed participants ($M_{age}$ = 23.8, *SD* = 3.2; 75% women) took part in the experiment in exchange for monetary reward. Participants signed an informed consent prior the participation in the study. Handedness was tested with the Edinburgh Inventory (Oldfield, 1971) modified by Salmaso & Longoni, 1986.

### *6.2.2. Apparatus and stimuli*

The apparatus and stimuli used in Study 2 were the same as the ones in Study 1. However, in this case the touchscreen monitor was vertically mounted to perform the upward or downward movements (see Figure 15).

### *6.2.3. Procedure and design*

In order to control for the differences within and between the experimental groups, participants rated the valence of the pictures 48 hours prior to the experiment. In the experimental task participants were presented with the same pictures on a vertically mounted touchscreen monitor. Then they were instructed to touch and subsequently move each picture by performing a vertical arm movement (see Figure 14). Specifically, one group of participants touched the pictures at the top edge of the screen and subsequently moved them towards a white square at the opposite bottom edge (i.e., downward arm movement). The other group touched the pictures at the bottom edge of the screen and subsequently moved them towards a white square at the opposite top edge (i.e., upwards arm movement). Following each movement, the picture just moved was presented again in a middle centred position on the touchscreen together with a 1-9 Likert scale below it, used to rate its valence. Immediately after this evaluation, the next picture was presented. In both sessions, the order of all pictures was randomized. Therefore, in this study the factor movement (downward vs. upward) was manipulated between subjects, whereas the factor valence category (positive vs. negative) was manipulated within subjects.

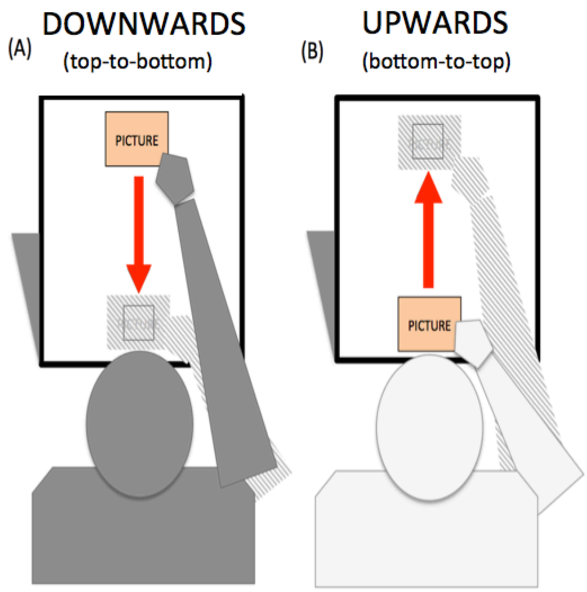


*Figure 15*. Depiction of the experimental setting in Study 2. A) One group of participants (n=30 each) swiping the pictures downwards on the touchscreen monitor (i.e., top-to-bottom); B) another group of participants (n=30) swiping the pictures upwards (i.e., bottom-to-top). Shaded gray areas represent the final arm and picture position.

## 6.3. Data analyses and results

All analyses were performed by means of linear mixed-effects models (LMM) via maximum likelihood with the software package SPSS 21.0 (IBM). Valence ratings greater or less than 3SDs of each subject average in the positive and negative pictures' categories and of each picture average in each experimental group were excluded from further analyses (1.17%). The modelling of the resulting data, as elaborated next, reached better goodness of fit ($AIC$ = 7255.6) compared to a random-factor-only model, ($AIC$ = 8365.7), $\chi^2 = 15.1$, $p < 0.01$. To calculate $p$ values estimates for the fixed-effects, a Type III Satterthwaite approximation was used (e.g., Carr et al., 2016; West et al., 2014).

Valence evaluations were analysed with a 2 (Movement: upward vs. downward) x 2 (Valence category: positive vs. negative), fixed-effects structure. Movement was manipulated between subjects whereas valence category was manipulated within subjects. Valence evaluations of the baseline were used as a control covariate. Subjects and pictures were included as random factors with random intercepts in order to account for between-subjects and between-pictures differences on the valence evaluations.

The analysis showed a significant main effect of valence category, $F(1,79) = 355$, $p < 0.001$, indicating that positive pictures were rated more positively than negative pictures. The main factor Movement was not significant, $F(1,59) = .15$, $p = 0.68$, indicating no main influence of the type of movement on the evaluation of the pictures. Interestingly, the interaction between movement and valence category was significant, $F(1,2263) = 16.3$, $p = 0.001$. Post-hoc analyses of this interaction using Bonferroni correction revealed that:

a) Contrary to findings of previous studies, positive pictures moved downwards (top-to-bottom) were rated more positively than positive pictures moved upwards (bottom-to-top), $t(126) = 2.5$, $p = 0.013$, d = .56

b) Negative pictures moved upwards (bottom-to-top) tended to *less* negative ratings compared to negative pictures moved downwards (top-to-bottom), $t(110) = 1.92$, $p = 0.058$, d = .35 (see Figure 16).

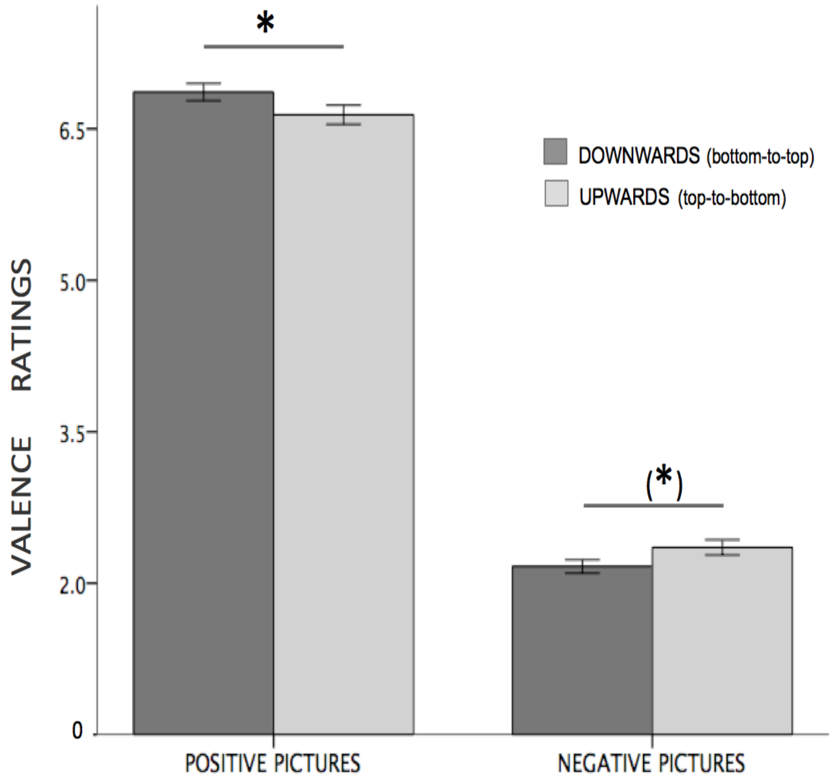


*Figure 16.* Valence ratings of positive and negative pictures after downwards (i.e., top-to-bottom) versus upwards (i.e., bottom-to-top) swiping gestures on the touchscreen monitor. *$p$<0.05; (*) $p$<0.1; error bars represent confident intervals at 95%

## 6.4. Discussion

Study 2 examined whether interacting emotional pictures on a touchscreen monitor, with vertical swipe moving gestures, would influence participants' valence appraisals towards the pictures. To do so, participants touched the pictures and moved them with their right hand either upwards (from the bottom to the top) or downwards (from the top to the bottom) on the touchscreen monitor. If touching the pictures during performing the swipe gesture is irrelevant for judging the pictures' valence, it was expected that both positive and negative pictures would be rated more positively following upward movements and more negatively rated following downward movements, thus, suggesting that the movement direction influenced the subjects' valence appraisals regardless the valence category of the pictures (Sasaki et al., 2015; *moving direction hypothesis*). In contrast, if touching the pictures during performing the moving gesture is relevant for rating the pictures' valence, it was expected that the valence of the picture that sticks to the hand would be into the focus of attention together with the valence of its location. This would suggest a link between the valence of the picture and the valence category of its location (cf. Brucker et al., 2017; *touch hypothesis*). The resulting pattern of the present study supports the *touch hypothesis*. Specifically, positive pictures were rated more positively when they were moved from the top to the bottom on the touchscreen. Interestingly, negative pictures tended to *less* negative ratings when they were moved from the bottom to the top. Specifically, the results support the notion that pictures were more positively rated when they were touched in a location whose associated valence category matched the valence category of the moved picture (i.e., positive picture – starting location of the swipe gesture in the upper "*positive*" space and negative picture – starting location of the swipe gesture in the lower "*negative*" space of a touchscreen). In contrast, valence ratings of both positive and negative pictures were rather negative when the associated valence of the starting location of the swipe gesture did not match their valence category of the moved picture (i.e., positive picture – starting location of the swipe gesture in the lower *"negative"* space and negative picture – starting location of the swipe gesture in the upper *"positive"* space of a touchscreen screen).

Indeed, this effect on the negative pictures might appear at first sight as incongruent due to the fact that both the valence category of the picture and the valence associated to the bottom space are negative. However, former findings indicate that a match between the valences of the stimuli and their vertical location would be rated more positively compared to a mismatch (cf. Marmolejo-Ramos et al., 2016; Meier & Robinson, 2004). For example, Schnall and Clore (2004) showed that positive words presented at the upper side of a piece of paper and negative words presented at the lower side, were rated more positively. In contrast, the opposite mapping (positive word – lower side and negative word – upper side) resulted in more negative ratings. The authors suggested that this result-pattern might arise because of the valence match' between the stimuli and its location are perceived as more congruent compared to a mismatch, thus, leading to more fluent processing of the information (cf. Openheimer, 2008).

Therefore, this result pattern supports the valence-space compatibility effects by which positive valence is associated "up" and negative valence are associated "down".

Interestingly, another striking effect may be derived from this pattern of results. Swiping both positive and negative pictures downwards, thus, from the upper area on the touchscreen to the bottom, resulted in a reinforcement effect (positive pictures were more positive rated and negative pictures more negative rated). In contrast, swiping the pictures upwards, from the bottom to the top, resulted in an attenuation effect. Thus, it appears that downward movements (or swiping the pictures from the upper area on the screen) was relevant to intensify the subjects' appraisals towards the emotional pictures (see Table 5).

Nonetheless, why should touching a picture directly with the hand lead to a different valence rating compared to a picture not touched directly?

In this case research on near-hand effect has shown that stimuli presented in the proximity of an individual's hand are better attended than those taking place in distal places to the hand. This suggests that hand proximity towards a stimulus influences the attention deployed to this stimulus and its location, increasing the depth of its visuospatial processing (e.g., processing of pictures in its location; Reed et al., 2006). It has been argued that this deeper visuospatial processing respond to a mechanism of attentional disengagement (or attentional prioritization) to the space near the hands.

Therefore, the findings of Study 2 seem to support the two research question of this dissertation, namely, the affective influence of a swipe gesture (RQ1) and the compatibility effects in line with the valence-space metaphor (RQ2). Moreover, it appears that, as in Study 1, the movement' starting point plays an important role in the findings.

Table 5. Influence on valence appraisals (ratings) stemming from the match between the valence (in parenthesis) associated with: a) pictures' valence category, and b) movement' starting point (vertical).

| *Picture' valence category* | *Movement' starting point* | *Valence' match* | *Influence on valence appraisals (ratings)* |
|---|---|---|---|
| Positive (+) | Top (+) 🡇 | Match | More positive (R) |
| | 🡅 (-) Bottom | Mismatch | Less positive (A) |
| Negative (-) | Top (+) 🡇 | Mismatch | More negative (R)* |
| | 🡅 (-) Bottom | Match | Less negative (A)* |

Note: *(marginal effect); (R) Reinforcement; (A) Attenuation

## Study 3: Swiping emotional pictures in a sagittal touchscreen space

The goal of Study 3 was to investigate whether manipulating emotional pictures by means of swipe gestures on a sagittal touchscreen space (i.e., backward or forward) would influence subjects' valence appraisals towards the pictures. This study builds upon former findings indicating that:

a) Performing forward and backward arm movements in response to valence-laden stimuli resulted in motor compatibility effects (i.e., response times; affect-to-action link). Specifically, a match between the valence category of a stimulus and the directional arm movement (i.e., positive – backwards and negative – forwards) led to faster motor responses. In contrast, a mismatch (i.e., positive – forwards and negative – backwards) led to slower motor responses (i.e., self-reference frame effects; Freina et al., 2009). Consistent with these findings, recently it has been found that performing forward and backward swiping gestures on a touchscreen device with emotional pictures resulted in a similar result-pattern (Kraus, 2014). Nonetheless:

b) Holding flexion-like approach and extension-like avoidance arm postures influenced valence appraisals towards presented affective stimuli (i.e., action-to-affect link). Specifically, a match between the valence category of a stimulus and the arm posture (i.e., positive – flexion and negative – extension) led to more positive appraisals. In contrast, a mismatch (i.e., positive – extension and negative – flexion) led to more negative appraisals (e.g., Centerbar & Clore, 2006).

In addition:

c) positioning a valence-laden picture in a proximal (i.e., close) or distal (i.e., far) location with regard to a subject' position, may affect the visuospatial processing of the picture (cf. Valdés-Conroy et al., 2014).

In light of these findings, participants in Study 3 manipulated emotional pictures in the sagittal touchscreen space by means of swiping gestures from proximal to distal locations (i.e., forwards) or from distal to proximal locations (i.e., backwards). As in Study 1 and 2, the participants reported the valence' appraisals towards the pictures in a numerical scale after performing these movements. Accordingly, the following hypotheses were derived:

## 7.1. Hypotheses

H.1. If performing forward and backward swipe interactions with the pictures is irrelevant to influence the subjects' valence appraisals towards the pictures, it is expected that displaying the pictures in the proximal location to the participant's position will stimulate their visuospatial processing. Therefore, the valence of positive and negative pictures could be reinforced (positive pictures more positively evaluated and negative pictures more negatively evaluated; *affect proximity hypothesis*). However:

H.2. If performing forward and backward swipe interactions with the pictures is relevant to influence the subjects' valence appraisals towards the pictures, a result-pattern of motor compatibility effects is expected (*motor compatibility hypothesis*). Specifically, a match between the valence category of the pictures and the affective movement (positive – backward; negative – forward) will result in more positive appraisals. In contrast, a mismatch (positive – forward; negative – backwards) will result in more negative appraisals.

## 7.2. Methods

### *7.2.1. Participants*

A total of 60 right-handed german speaking participants ($M_{age}$ = 24.2, $SD_{age}$ = 6.8; 83% women) took part in the experiment in exchange for monetary reward. Informed consent was signed prior the participation in the study. Handedness was tested with the German translation of the Edinburgh Inventory (Oldfield, 1971) modified by Salmaso & Longoni, 1985.

### *7.2.2. Apparatus and stimuli*

The apparatus and stimuli used in Study 3 were the same that the ones used in the two previous studies. However, in this case the touchscreen monitor was positioned lenghwise, thus, with the narrow edge facing the participants' position (see Figure 17).

### *7.2.3. Procedure and design*

In order to control for the differences within and between the experimental groups participants evaluated the valence of the pictures 48 hours prior to the experiment. In the experimental task, participants were randomly assigned to one of two experimental groups. One group of participants touched and subsequently moved the pictures on the touchscreen from a proximal location with regard to their position to a distal location indicated by an empty square (i.e., forward arm movement). The other group touched and subsequently moved each picture from a distal location to a proximal point (i.e., backward arm movement; see Figure 16). Following each movement, the picture just moved was presented again in a middle centred position on the touchscreen together with a 1-9 Likert scale below it, used to rate its valence. Immediately after this rating, the next picture was presented. In both sessions, the order of all pictures was randomized. Therefore, the factor movement (forward vs backward) was manipulated between participants, whereas the factor valence category (positive vs. negative) was manipulates within participants.

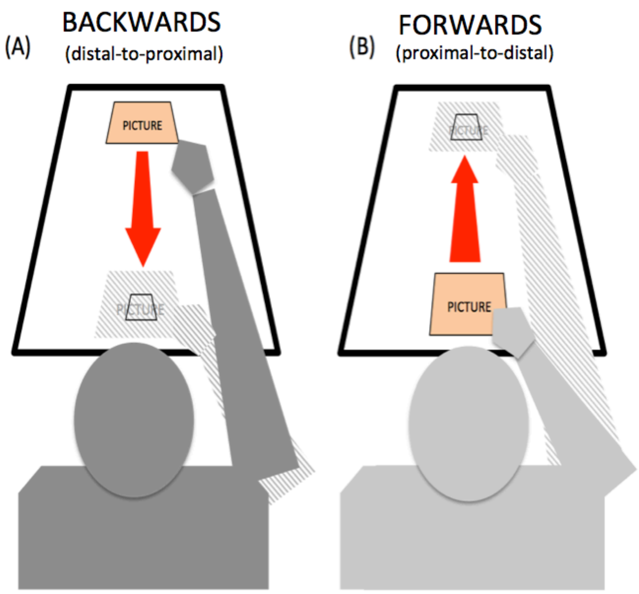


*Figure 17.* Depiction of experimental setting in Study 2: (A) one group of participants (n=30 ) swiping the pictures backwards (distal-to-proximal touchscreen' locations). (B) another group of participants (n=30) swiping the pictures forwards (proximal-to-distal touchscreen locations). Shaded gray areas represent the final arm and picture position.

## 7.3. Data analyses and results

All analyses were performed by means of linear mixed-effects models (LMM) via maximum likelihood with the software package SPSS 21.0 (IBM). This method has been found appropriated to simultaneously control the error variance with regard to subjects, stimuli and/or the subject x stimuli interactions (e.g., Baayen, et al., 2008; Barr, et al., 2013). Valence ratings greater or less than 3SDs from each subject average in the positive and negative pictures' categories and from each picture average in the forward and backward experimental groups were excluded from further analyses (1.5%). The ratings from one participant were not included in the analyses because of the excesive number of trial errors (>15%). The modelling of the resulting data, as elaborated next, reached better goodness of fit (*AIC* = 6840.5) compared to a random-factor-only model, (*AIC* = 8103.2), $\chi^2 = 13.28$, $p < 0.01$. To calculate *p* values estimates for the fixed-effects, it was used a Type III Satterthwaite approximation (e.g., Carr, Rotteveel, & Winkielman, 2016; West, Welch, & Galecki, 2014).

Valence evaluations were analyzed with a 2 (Movement: backwards vs. forwards) x 2 (Valence category: positive vs. negative), fixed-effects structure. Movement was manipulated between subjects whereas valence category was manipulated within subjects. Valence evaluations of the baseline were used as a control covariate. Subjects and pictures were included as random factors with random intercepts in order to account for between-subjects and between-pictures differences on the valence evaluations.

The analyses did not show a significant main effect of movement, $F(1,57) = .001$, $p = 0.98$. The valence category factor, on the contrary, showed significant effects, $F(1,99) = 293$, $p < 0.001$, indicating that positive pictures lead to more positive evaluations than negative pictures. Interestingly, the interaction movement x valence category showed high significant effects, $F(1,2200) = 13.2$, $p < 0.001$ (see Figure 18). Post-hoc analyses of this interaction using Bonferroni correction indicated that:

a) positive pictures tended to more positive ratings after backward (i.e., distal-to-proximal touschreen locations) than after forward movements (i.e., proximal-to-distal touchscreen locations), $t(126) = 1.95$, $p = 0.053$, $d = .34$.

b), negative pictures were *less* negatively rated after forward movements than after backwards movements, $t(101) = 1.98$, $p = 0.050$, $d = .34$.

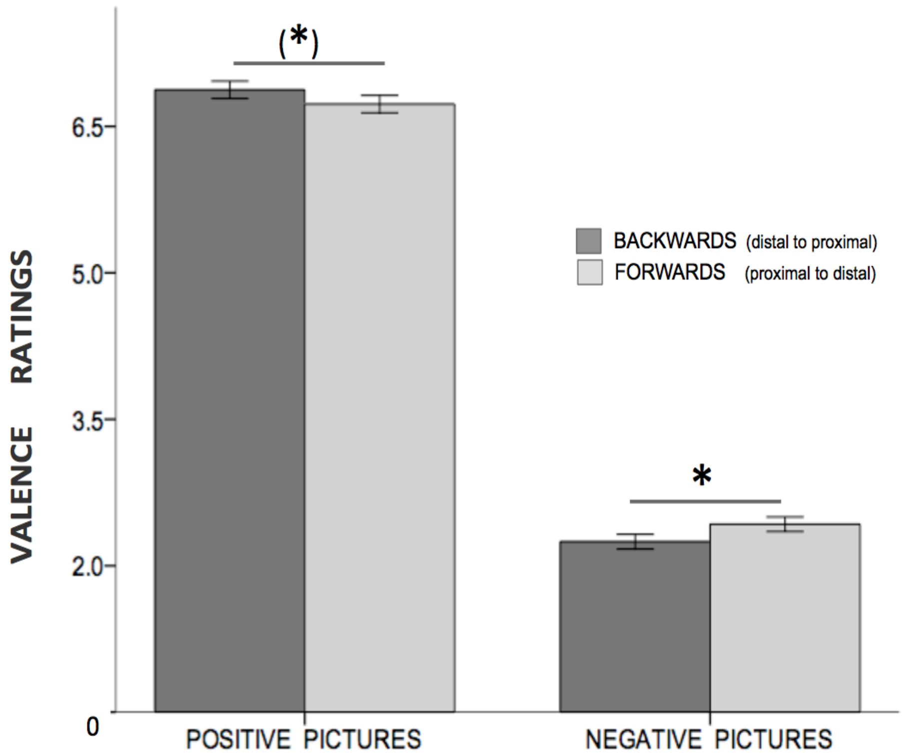


*Figure 18*. Valence ratings of positive and negative pictures after backwards (distal-to-proximal locations) versus forwards (proximal-to-distal locations) swiping gestures on the touchscreen monitor. *p<0.05; (*) p<0.1; error bars represent confident intervals at 95%

## 7.4. Discussion

Study 3 examined whether interacting emotional pictures on a touchscreen monitor by means of swipe interaction gestures in the sagittal touchscreen space, would influence participants' valence appraisals towards the pictures. To do so, participants touched the pictures and moved them with their right hand either from proximal to distal locations on the touchscreen (i.e., forward) or from distal to proximal locations (i.e., backwards). If performing forward and backward swipe interactions with the pictures is irrelevant to influence their valence rating, it was expected that displaying the pictures in a proximal location to the participant's position, would stimulate their visuospatial processing and thus would thus lead to a valence reinforcement of both, positive and negative pictures (*affect proximity hypothesis;* cf. Valdés-Conroy et al., 2014). In contrast, if forward and backward swipe gestures with the pictures are relevant to influence the pictures' valence ratings, compatibility effects from a match between the valence category of the picture and the performed movement were expected (*motor compatibility hypothesis*). Therefore, positive pictures moved backward (vs. forwards) would be more positively rated, whereas negative pictures moved forwards (vs. backwards) would be *less* negatively rated (cf. Centerbar & Clore, 2006). The result-pattern of Study 3 supports the *motor compatibility hypothesis*. Specifically, positive pictures tended to more positive ratings after backwards interaction gestures compared to forward interaction gestures. On the other side, negative pictures were less negatively rated after forward than after backwards interaction gestures. The results are in line with former studies suggesting that the distance regulation effects stemming from the performance of arm movements in the sagittal space influence the subjects' affective responses towards stimuli (e.g., valence appraisals). Therefore, in the present study, backward gestures on the touchscreen monitor reduced the distance between the pictures and the subjects' position, whereas forward gestures increased the distance. Interestingly, inspecting in more detail the results of this study revealed also a reinforcement effect. In this case, swiping the pictures backwards tended to more positive ratings of positive pictures and resulted in more negative ratings of negative pictures (see Table 6).

In conclusion, the novelty of these findings is twofold: a) beyond static arm positions (i.e., flexion or extension), directional interaction gestures performed in the sagittal space (backwards-approaching or distance reduction and forwards-avoiding or distance enlargement) may influence the valence apprasials upon emotional pictures, and b) the effects extend previous compatibility effects from the affect-to-action link reported by means of forward/backward swipe gestures with emotional pictures in a touchscreen environment (e.g., Kraus et al., 2014).

Table 6. Influence on valence appraisals (ratings) stemming from the match between the valence (in parenthesis) associated with: a) pictures' valence category, and b) forward and backwards movements.

| *Picture' valence category* | *Movement' direction* | *Valence' match* | *Influence on valence appraisals (ratings)* |
|---|---|---|---|
| Positive (+) | ➘ (+) Backwards | Match | More positive (R)* |
| | Forwards ⇖ (-) | Mismatch | Less positive (A)* |
| Negative (-) | ➘ (+) Backwards | Mismatch | More negative (R) |
| | Forwards ⇖ (-) | Match | Less negative (A) |

* (marginal significant); (R) Reinforcement; (A) Attenuation

# 8. General discussion

## 8.1. Summary and results

The present thesis investigated, from an embodied perspective, the potential of touchscreen interfaces as “positive technologies”. The increasing use of interactive technologies such as touchscreens (e.g., smartphones, tablets or touchscreen monitors) raises questions about the effects that these devices may have on users’ affectivity. In this regard Positive Technology (PT) is a recent research area concerned with how digital and interactive environments should be designed and used to promote users’ states of emotional well-being. In this regard, displaying valence-laden content (e.g. pictures) in interactive applications may serve to stimulate and examine positive or negative users’ affectivity (e.g., Riva, 2012). Interestingly, despite the increasing development and use of touchscreens, which allow for direct finger, hand or arm interaction gestures with digital content, it is unclear how this physical aspect may influence users’ affectivity. The present dissertation aimed to bring new insights on this question from theories and research on embodied cognition, which suggest that perception and action may influence cognitive and emotional functioning (e.g., Barsalou, 2008). Specifically, studies focused on interactions with touchscreen interfaces (cf. Embodied Interaction; Dourish, 2004) indicate that manipulating images with directional interaction gestures such as swiping may lead to meaningful and enriched visuospatial processing of the content (e.g., Brucke et al., 2016; Kranz et al., 2012). On the other side, experimental research in psychology supports the notion that positive and negative emotional valence may be mentally represented according to bodily dimensions of space (i.e., horizontal, vertical, and sagittal; cf. Crawford, 2009). Moreover, converging findings also indicate that the processing of valence-laden stimuli is strongly associated with spatially directed arm movements. Accordingly, two pivotal research questions were formulated. The first referred as to whether manipulating affective pictures on a touchscreen interface by means of directional swiping gestures could influence an affective experience (i.e., valence appraisals towards the pictures). The second question considered whether directional swipe interactions could influence valence appraisals according to valence-space associations, as indicated by previous experimental studies.

Against this background, and in line with the concern of a Positive Technology framework, three studies examined the potential affective influence of swipe interaction gestures performed in: a) the horizontal (Study 1), b) vertical (Study 2), and c) sagittal (Study 3) touchscreen space, on the subjects' valence appraisals towards the pictures.

a) In Study 1 right-handed participants swiped positive and negative pictures on a touchscreen-monitor either leftwards (i.e., from right to left sides) or rightwards (i.e., from left to the right sides). Besides, participants used only their dominant right or non-dominant left hand. After each movement, they rated the valence of the pictures on a numerical scale. The crucial finding revealed that a match between the valences associated to 1) the pictures' valence category (i.e., positive or negative), 2) the interacting hand (i.e., dominant right – positive and non-dominant left – negative; cf. de la Vega, 2013), and 3) the movement' starting point (i.e., dominant right side – positive and non-dominant left side – negative; cf. Body Specificity Hypothesis –BSH–; Casasanto, 2009), reinforced the subjects' valence appraisals towards the pictures. In other words, swiping positive pictures with the dominant right hand from right-to-left sides on the touchscreen (vs. from left-to-right sides) resulted in more positive ratings of the pictures. On the contrary, swiping negative pictures with the non-dominant left hand from left-to-right sides (vs. from right-to-left sides) resulted in more negative ratings of the pictures. Indeed, the findings seem to support the positive connotation of the dominant right space as BSH research has indicated. Nonetheless, beyond lateral spaces, the findings in Study 1 support a *hand and movement – hypothesis* suggesting that not only hand dominance but also lateral movements of the hands influence subjects' affectivity as reflected in their valence appraisals towards the pictures.

b) In Study 2, participants swiped positive and negative pictures on a vertically mounted touchscreen monitor either downwards (from top to bottom locations), or upwards (from bottom to top locations). The results highlighted a congruent match between the valences associated to 1) the pictures' valence category (i.e., positive or negative), and 2) the movement' starting point (i.e., up – positive and down – negative; cf. Meier & Robinson, 2004). In other words, swiping positive pictures from the top area of the touchscreen (vs. from the bottom area) resulted in more positive pictures' ratings, whereas swiping negative pictures from the bottom area (vs. from the top area) suggested *less* negative pictures ratings. This pattern of results extended previous findings indicating valence-space congruency effects by which positive and negative stimuli (e.g., words) were more positively rated when presented at their congruent locations (positive – up; negative – down; Schnall & Clore, 2004). More important, the findings in Study 2 point to the relevance of touching the pictures as influential in subsequent valence appraisals, suggesting higher processing of information near the interacting hand (cf. Brucke et al., 2016). That was considered in light of a previous study examining the influence of vertical touchscreen gestures on valence appraisals of emotional pictures, but without interacting them directly with the hand.

c) Finally, in Study 3, participants swiped positive and negative pictures backwards (from distal to proximal locations) or forwards (from proximal to distal locations). The results highlighted an affective matching between 1) the interaction gesture (i.e., backward and forward; Cacioppo et al., 1993), and 2) the picture's valence category (i.e., positive or negative). In other words, swiping positive pictures backward indicated a more positive rating tendency of said pictures, whereas moving negative pictures forwards resulted in *less* negative pictures' ratings. These findings are in line with approach-avoidance compatibility effects, which suggest that backward and forward movements may be interpreted as the distance regulation between two elements, in this case, the participants and the pictures (e.g., Freina et al, 2009). Accordingly, movements reducing distance with positive pictures (i.e., backwards) and increasing distance with negative pictures (i.e., forwards) resulted in more positive ratings of the pictures' valence. Here, a reinforcing effect was revealed when swiping the pictures backward (positive pictures showed a more positive rating tendency and negative pictures were more negative rated). Furthermore, the results in Study 3 extended previous findings in two important points: a) previous research reports the influence of static flexion and extension arm positions on valence appraisals towards presented stimuli (e.g., Caciopo et al., 1993), whereas backward and forward movements are typically performed in response to presented valence-laden stimuli. The findings of Study 3 show that these directional movements may be influential on valence appraisals as well. On the other side b) a recent study reported approach-avoidance compatibility effects when performing forward and backwards swipe gestures with emotional pictures on a touchscreen device (Kraus et al., 2014). In this case, these effects tied in an affect-to-action link, namely, the influence of the emotional content on motor execution. Study 3, in contrast, show that forward and backward arm movements influence valence appraisals towards stimuli in a comparable setting.

In the following, the findings of the three reported studies will be discussed in connection with the two formulated research questions at the beginning of Chapter 4. The potential practical implication of the findings, as well as, strengths and limitations of the present dissertation will be addressed from now on.

## 8.2. Are directional swipe gestures useful to influence subjects' affective responses?

Against the background of Positive Technology fields, the present thesis aimed at investigating whether bodily interactions with touchscreen interfaces could influence users' affectivity. Accordingly, the first important question was to figure out how such bodily interactions should be performed to influence affect. One possible approach came from research on Embodied Interaction and specifically embodied touchscreen interactions (Kranz et al., 2012). In light of the studies described in Chapter 2, it appeared that interacting with images by means of swipe gestures influenced their related visuospatial processing, more when considering the near-hand effects or higher visual processing of stimuli due to hand proximity (Brucker et al., 2017). Furthermore, the SwAAp (Swipe Approach-Avoidance Procedure; Kraus & Hoffman, 2014) gives strength to the idea that swipe interaction gestures are good candidates to potentially influence users' affectivity. Therefore, in answer to the formulated research question, all three studies reported in the present thesis suggest that manipulating emotional pictures by means of directional swipe gestures influences users' affectivity; concretely, the subject's valence appraisals (i.e. numerical ratings) towards the pictures. However, the effects derived from these swipe gestures differed between the studies. This aspect will be discussed as part of the answer to the second research question driving this thesis.

## 8.3. May embodied touchscreen interactions (i.e., swiping) reflect valece-space (mis) matchings similar to those in the embodiment literature?

The three studies highlight a common and relevant twofold finding. On one side, they all revealed reinforcement and attenuation effects with regard to the pictures' valence category. Concretely, when swiping the pictures downwards (Study 2) and backwards (Study 3) subjects' appraisals were more positive towards positive pictures and more negative towards negative pictures. In contrast, upwards and forwards movements led to the opposite effect, namely, attenuation of the pictures' valence. Study 1 also indicated reinforcement and attenuation effects but they will be discussed in light of the second interpretation of the findings. In this regard, the second striking finding is that all the studies indicated affective matchings between the valence of the pictures and the performed interaction gestures. Specifically, it appeared that when the pictures' valence category (positive or negative) and the directional swipe gestures (horizontal, vertical, and sagittal) matched, the subjects' appraisals toward the pictures were more positive. In contrast, when these two elements mismatched the subjects' valence appraisals were more negative. Nonetheless, this "positive-match effect" was not to the extent of the boundaries, namely, it came about exclusively when swiping the emotional pictures with the dominant right hand (see Table 7), but not when swiping the pictures with the non-dominant left hand (see Table 8). Furthermore, the (mis) matching effects in the three studies also pointed to crucial differences. These differences will be discussed next based on two main mechanisms: a) Matching effects associated with the movement' starting point (Studies 1 and 2), and b) matching effects associated with the movement' affective meanings (Study 3).

### 8.3.1. Matching effects associated with the movement' starting point

Study 1 investigated whether swiping emotional pictures in the horizontal touchscreen space (rightwards/leftwards) would influence subjects' valence appraisals of pictures. Study 2 on the other side, investigated similar effects by means of swiping interaction gestures performed in the vertical touchscreen space (upwards/downwards). Interestingly, the findings of both studies revealed that matches between the pictures' valence category (positive or negative) and the valenced connotation of the movement' starting point (see Table 7) resulted in more positive valence appraisals. To put it simply, positive pictures were rated as more positive and negative pictures were rated as *less* negative. Conversely, mismatches resulted in more negative valence appraisals; positive pictures were rated as *less* positive and negative pictures were rated as more negative. However, the findings also suggested and important boundary in this trend: matches from swipe gestures of the non-dominant left hand resulted in negative effects. Indeed, despite that Study 1 and 2 share the same movement' starting point as an explanation of their effects, their underlying dynamics are different. Specifically, while the effects in Study 1 seem to highlight contrasts between the dominant and non-dominant hand, the effects in the vertical space might be more related to near-hand effects. These issues will be discussed in the next two sections.

**Table 7**. Swipe gestures with the dominant right hand; Table showing (mis) matches between valences (in parenthesis) of the pictures' valence category and: a) movement' starting point (Horizontal; Study 1), b) movement' starting point (Vertical; Study 2), and c) movement' affective meaning (sagittal; Study 3). Arrows indicate the movement direction.

| *Picture Valence' category* | *Directional Swipe gesture* | *Valence (Mis) match* | *Effects on pictures' valence appraisals* |
|---|---|---|---|
| a) Horizontal | | | |
| Positive (+) | 🡐 Right (+) | Match | More positive (R) |
| | Left (-) 🡒 | Mismatch | Less positive (A) |
| Negative (-) | 🡐 Right (+) | Mismatch | n.s. |
| | Left (-) 🡒 | Match | n.s. |
| b) Vertical | | | |
| Positive (+) | Top (+) 🡓 | Match | More positive (R) |
| | 🡑 Bottom (-) | Mismatch | Less positive (A) |
| Negative (-) | Top (+) 🡓 | Mismatch | More negative (R)* |
| | 🡑 Bottom (-) | Match | Less negative (A)* |
| c) Sagittal | | | |
| Positive (+) | 🡖 Backwards (+) | Match | More positive (R) |
| | Forwards (-) 🡔 | Mismatch | Less positive (A) |
| Negative (-) | 🡖 Backwards (+) | Mismatch | More negative (R)* |
| | Forwards (-) 🡔 | Match | Less negative (A) * |

Note: n.s. (non-significant effect); *marginal effects; (R) Reinforcement; (A) Attenuation

**Table 8**. Swipe gestures with the non-dominant left hand. Table showing (mis) matches between valences (in parenthesis) of the pictures' valence category and the movement' starting point (Horitontal: Study 1)

| *Picture Valence' category* | *Directional swipe gesture* | *Valence (Mis) match* | *Effects on pictures' valence appraisals* |
|---|---|---|---|
| Positive (+) | 🡐 (+) Right | Match | n.s. |
| | Left side (-) 🡒 | Mismatch | n.s. |
| Negative (-) | 🡐 (+) Right | Mismatch | Less negative (A) |
| | Left side (-) 🡒 | Match | More negative (R) |

Note: n.s. (non-significant); (R) Reinforcement; (A) Attenuation

8.3.1.1. Hand dominance and the lateral body space

Study 1 is the only one of the three studies where participants manipulated pictures with their non-dominant left hand. This was motivated by findings of the Body Specificity Hypothesis (BSH; Casasanto, 2009) indicating that right-handers associated the space surrounding the dominant right hand with positive valence because the natural experiences of fluency related to this hand. In contrast, the space surrounding the non-dominant hand was associated with negative valence presumably due to its lesser fluency. Further research based on the BSH also examined affective associations between valence-laden stimuli and motor responses of the dominant and non-dominant hand. In this regard, de la Vega et al., (2013) indicated that the dominant right hand responded faster to positive stimuli whereas the non-dominant left hand responded faster to negative stimuli. In contrast, Milhau et al. (2014) indicated that both, dominant right and non-dominant left hand responded faster to positive stimuli when the hands moved to their congruent spaces (i.e., right hand to the right; left hand to the left). Yet, Study 1 is probably the first one in to investigate all these affective associations with laterality as integrated in one single touchscreen setting (i.e., space, hand and movement). One may wonder that the complexity derived from the integration of these two aspects (i.e., valence-space associations and touchscreen interface) made unclear what effects to expect considering first the manipulation of the objects and second the performance of movements involving the dominant and not dominant space. Nevertheless, the findings of Study 1 revealed an interesting result-pattern: a) Valence appraisals towards positive pictures were differently influenced only by participants using their dominant right hand; in contrast b) valence appraisals towards negative pictures were differently influenced only by participants using their non-dominant left hand. At first sight, this finding resembles the ones reported by de la Vega (2013) indicating a match in form of positive pictures – right hand and negative pictures – left hand. However, these matches were extended by a third component, namely, the movement' starting point or in other words the space from where the pictures were touched and subsequently moved (see Table 7a and Table 8). In consequence, the matching' effects for the right hand (i.e., positive picture, positive hand, and positive right side) resulted in more positive appraisals (also in Studies 2 and 3), whereas the matching' effects for the left hand (i.e., negative picture, negative hand, negative left side) resulted in more negative appraisals. One question that may arise here, is why the movement's starting point did not appear as relevant when swiping negative pictures with the right hand or positive pictures with the left hand, especially when considering that in Study 2 the matchings effects influenced both the appraisals of positive and negative pictures.

A potential explanation for these contrasting findings might follow the next rationale: In Study 1, swiping the pictures in the horizontal touchscreen space required crossing the participants' middle bodyline but this was not the case for vertical or sagittal movements (see Figure 19).

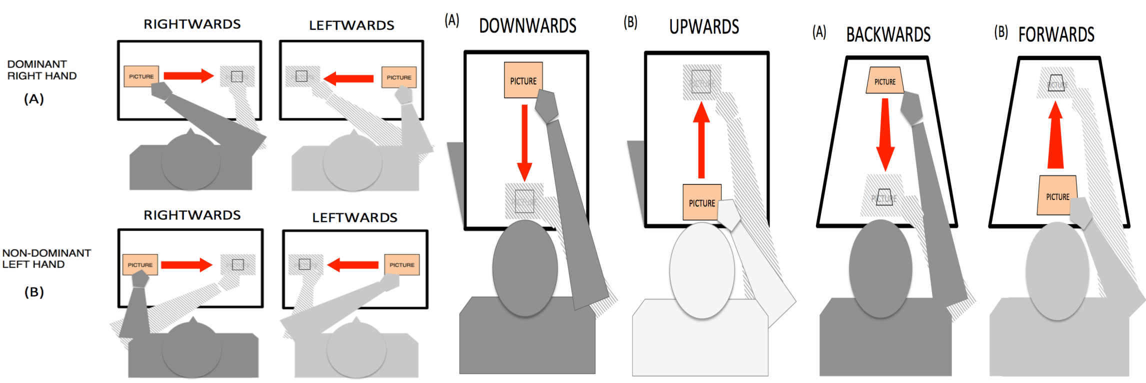


*Figure 19*. Depiction of the experimental settings corresponding to the three resported studies.

Therefore, crossing the middle bodyline could create a situation where right and left spaces became more salient. In light of the BSH this could make a strong point due to the affective connotation of the lateral spaces (i.e., dominant right space – positive and non-dominant left space – negative). Indeed, when inspecting the effects in more detail, it was observed that swiping negative pictures with the non-dominant left hand from the right *positive* space, resulted in less negative pictures' ratings, which speak in favour of the BSH.

Neuroimaging studies may help to understand the matching effects in Study 1. For example, studies focused on brain asymmetries suggest that movements of the hands are contralaterally connected to the brain hemispheres (i.e., right hand – left hemisphere and left hand – right hemisphere), and this connection might potentially lead to different affective responses when hand movements are performed at the dominant or non-dominant spaces (cf. Cretenet & Dru, 2004; Davidson, 2004). In line with this reasoning, Schiff and Lamon (1994) found that one group of right-handed participants evaluated presented stimuli as more positive when they were asked to perform movements with the dominant right hand in the dominant right space (e.g., squeezing a ball) whereas another group evaluated the same stimuli as more negative when performing movements with the non-dominant left hand in the non-dominant left space (see also Harmon-Jones, 2006). These findings seem to support a match between a) the dominant right hand with positive valence, particularly in the right space, and b) the non-dominant left hand with negative valence, particularly in the left space. Interestingly this rationale could potentially explain why in Study 1, the matching effects derived from swiping gestures of the non-dominant left hand resulted in more negative appraisals.

Nevertheless, beyond the affective connotation associated with the non-dominant hands in non-dominant space, the findings from Study 2 support a different and important aspect suggesting the relevance of the movement's starting point: the hand proximity to the pictures might have enforced an affective match between the pictures' valence category and the valence associated with the vertical spaces or, in this case the movement' starting point.

8.3.1.2. Near-hand effect and affective touchscreen' interaction

As above-mentioned Study 2 investigated whether manipulating emotional pictures by means of swipe gestures on the touchscreen vertical space would influence participant's affectivity. Indeed, as in Study 1, the findings in Study 2 point to the notion that the movement' starting point played an important role for the subsequent pictures' ratings. However, in order to clarify these effects let us recall the motivation of this study. This study builds upon the Conceptual Metaphor Theory (CMT; Lakoff & Johnson, 1980) an related experimental research, which suggest that positive stimuli (e.g., often emotional words or metaphorical language expressions; Marmolejo-Ramos, Montoro, Elosúa, Contreras, & Jiménez-Jiménez, 2014) is processed better at upper spaces or with upward movements, whereas in contrast, negative stimuli are processed better in lower spaces or with downward movements. This has usually been termed as the valence–space metaphor effect. In line with this idea, Sasaki et al. (2015) conducted a study pivotal to understand the effects in Study 2. Sasaki and colleagues examined whether performing upward or downwards swipe gestures on a vertically mounted touchscreen monitor would influence subjects' valence appraisals towards previously presented IAPS emotional pictures (including positive and negative). The crucial point here is that participants did not interact directly with the pictures, they just observed them on the screen and once disappeared participants performed the vertical movement. The authors reported that upward movements lead to more positive pictures' ratings, but downward movements lead to more negative pictures' ratings. Moreover, this was a main effect of movement regardless of the valence category of the picture.

Now, how these findings tie to Study 2? The results in Study 2 suggested that touching positive pictures and swiping them downwards (from the top area to the bottom area on the vertically mounted touchscreen), resulted in more positive pictures' ratings. Interestingly, touching negative pictures and swiping them upwards (from the bottom area to the top area) resulted in *less* negative pictures' ratings. Therefore, the first important difference with the study by Sasaki et al. was the interaction between movement and the picture' valence category. However, the more plausible prediction according to the valence-space metaphor for vertical movements would be that swiping upwards positive pictures would result in more positive ratings, whereas swiping downwards negative pictures would result in *less* negative ratings (cf. Schnall & Clore, 2004); in other words, a match between the picture' valence category and the directional movement resulting in more positive ratings. Interestingly, this does not seem to follow from Study 2. Instead, it appeared that what mattered was the upper or lower location from where the pictures were moved, hence, the movement' starting point. This suggested that, in contrast to Sasaki's study, touching the pictures directly with their hand was indeed relevant for subsequent affective appraisals.

Let us clarify the potential rationale behind this effect. As elaborated in preceding sections of this dissertation, one important characteristic of touchscreen interfaces is that they enable the integration of different sensory modalities such as vision, touch and movement. In line with this notion, the study by Brucker et al. (2017) addressed how these aspects could influence the processing of pictures displayed on a touchscreen environment. Their results indicated that touching pictures directly with the hand and swiping them on a large-scale touchscreen influenced the processing of the pictures' content compared to not touching them directly. This finding suggested the activation of attentional mechanisms leading to the enhanced visuospatial processing of the stimuli due to hand proximity (i.e., near-hand effect; cf. Abrams et al., 2008). Although the present dissertation did not investigate near-hand effects in detail, one may argue that consistent with the study by Brucker et al. (2017), touching and moving emotional pictures in a touchscreen environment might potentially influence their visuospatial processing too. Accordingly, this might lead to interpreting that, in Study 2, the processing of the emotional pictures near the hand could have been improved, highlighting the link between the positive or negative valence of the picture and the valence associated with the vertical space where the picture appeared (i.e., up – positive; down – negative; Meier & Robinson, 2004). Consequently, that could potentially influence subsequent valence appraisals.

Interestingly, that also leads to the question, could it be the case that the findings in Study 1 were also partially due to a near-hand effect? As discussed in the previous section, the movement's starting point was central to understanding the effects (i.e., right space – positive; and left space – negative). From this perspective it is also conceivable that touching the pictures at the right or left spaces highlighted a link between hand, picture and space. This is a question that, so far, is only open to speculation and would need further examination.

Finally, the last question driving this section refers to the aspect of why manipulating emotional pictures in the sagittal touchscreen space (Study 3) did not follow the rationale of the movement's starting point.

8.3.2. Matching effects associated with the affective meaning of movements

An important difference between study 3 and studies 1 and 2 was that the pictures' valence ratings were not influenced by the movement' starting point, this mechanism does not seem to apply here. Accordingly, why might be the reason for such differences considering that in all studies the subjects moved the pictures from initial to end spaces?
Study 3 was framed in the so-called approach-avoidance behavioural tendencies, namely, the tendency to approach positive things but to avoid negative things. Indeed, research in this domain has reported compatibility effects by which a match between an arm movement connoting approach or avoidance meanings and the valence category of stimuli results in more positive appraisals toward the stimuli (i.e., arm flexion as approach – positive stimuli; arm extension as avoidance – negative stimuli). A mismatch, in contrast, results in more negative appraisals (i.e., arm flexion – negative valence; arm extension – positive valence; Centerbar & Clore, 2006). Nevertheless, arm flexion and extension, in this case, are manipulations that require holding the hands statically positioned on a surface.

In contrast, manipulating the pictures in study 3 required directional backwards or forward swipe gestures. A previous study using a touchscreen device has also manipulated emotional pictures with such movements (Kraus et al., 2014). However, forward and backward movements are mostly used in paradigms that investigate how fast is performed the movement in response to an affective stimulus (i.e., affect-to-action link) rather than how a movement may influence an affective response (action-to-affect link). Nonetheless, from an embodied touchscreen interaction perspective, the most interesting aspect is that manipulating an object with the hands may enforce the self as reference in a task (Freina et al., 2009), what may confer forward and backward movements specific meanings: backwards means or is interpreted as “approach” whereas forward means or is interpreted as “avoidance”. This remarks a crucial difference with regard to lateral or vertical arm movements, which affective connotation or “meanings” may be apparently hindered if the affective connotation of the spatial locations co-occurs simultaneously (i.e., right/up – positive; left/down – negative).

Against this backdrop, the goal of study 3 was twofold: a) to examine the potential influence of directional backward and forward movements on the pictures’ valence ratings, thus, it was expected similar match effects associated with flexion and extension positions; in addition b) it was inspected the possibility that the spatial locations in the sagittal dimension (i.e., proximal or distal) could also hinder the potential backward and forward movement’ effects (cf. Valdés-Conroy et al., 2014).

In this regard, it was devised a setting were subjects manipulated the pictures either from proximal to distal locations on the touchscreen (i.e., forwards) or from distal to proximal locations (i.e., backwards). The findings in study 3, however, were straightforward. A trend indicated that swiping positive pictures backwards resulted in more positive ratings compared to swiping positive pictures forwards. In contrast, swiping negative pictures forwards resulted in *less* negative ratings compared to swiping this pictures backwards. Interestingly, a common aspect of this study and studies 1 and 2 is the *reinforcement* and *attenuation* effects with regard to the pictures’ valence category. Reconsidering study 3 from this view, one may conclude that swiping the pictures backwards resulted in not only more positive ratings of positive pictures but also in more negative ratings of negative pictures. On the contrary, swiping the pictures forwards attenuated the valence of both, positive and negative pictures. Therefore, in this case, it seems that rather than the movement’ starting point, what influenced the pictures’ valence ratings was the perception of the movements as meaningful actions in terms of approach-avoidance. The underlying mechanism of these effects would follow the rationale of movements that regulate the distance between the self and an object. In study 3, swiping the pictures backwards decreased the distance between the subject and the picture whereas swiping the pictures forwards increased the distance, hence, such distance regulation resulted in approach-avoidance compatibility effects (e.g., Seibt et al. 2007).

Against the backdrop of the three studies presented in this thesis, it seems that the findings show important differences as, for instance, the relevance of the movement' starting point (Study 1 and 2) or, in contrast, the movements' affective meaning (Study 3). Interestingly, the studies also share mutual aspects. This is leading to the question whether it is possible to explain the findings from a common perspective. The next section will discuss this point and then, it will let pass to highlight strengths and limitations on the piece of research presented in this dissertation.

## 8.4. Might a common mechanism integrate all the findings?

Although the three studies of this dissertation are framed in an embodied cognition approach-view, the reported findings appeared to be in line with different theoretical frameworks. Findings from Study 1 were explained against the background of the Body Specificity Hypothesis (Casasanto, 2009) where dominant and non-dominant hands play a fundamental affective role. Findings stemming from Study 2 were coherent with the valence-space metaphor following the structure: "Positive is up and negative is down" (cf. Schnall & Clore, 2004). Finally, findings in Study 3 fitted in approach-avoidance theoretical approaches (e.g., Centerbar & Clore, 2006). However, considering the three studies from an embodied touchscreen interaction perspective, one may wonder whether it would be possible to integrate all the findings under the umbrella of a common explanatory mechanism. In order to approach this issue, it might be necessary to pay attention first to some of the elements that these studies share in common. For example:

a) First, all the participants were right-handed. Therefore it is reasonable to think that they all relayed on similar valence-space mental representations, and especially those concerning the horizontal space (i.e., dominant right – positive; non-dominant left – negative).

b) The second aspect refers to the fact that all participants manipulated the pictures directly with the hands on a touchscreen monitor. Interestingly, this makes also plausible that all participants benefited from potential near-hand effects or higher visuospatial processing of the pictures due to the hand proximity to the stimuli (cf. Brucker et al., 2017).

c) Finally, in all studies participants were instructed to perform one single action, which was to move a picture on the touchscreen towards an empty square. This procedure was ideated to examine the unilateral influence of every moving interaction on the subjects' valence appraisals towards the pictures. Such unilateral bodily manipulations are quite usual in research falling in the action-to-affect link.

Interestingly, according to some theoretical paradigms in psychology, this procedure could also be re-interpreted to indicate that all participants manipulated the emotional pictures according to an action plan. For example, paradigms of action planning such as the Theory of Event Coding (i.e., TEC; Hommel, 2015; Hommel, Müsseler, Aschersleben, & Prinz, 2001) stem from a cognitivistic ideomotor approach (e.g., Laird & Bresler, 1990), which postulate that we are active agents that perform actions to reach particular outcomes. Specifically, the TEC proposes that planning or executing an action integrates the mental representation of event codes from both, perceptual features within a situation or a task and the outcome of an action. These event codes, in turn, would be temporally bound, influencing, for instance, the execution of an action (e.g., Lavender & Hommel, 2007; Zmigrod & Hommel, 2013). According to this rationale, one may argue that in the three studies, planning physical interactions with the valence-laden emotional pictures on a touchscreen monitor could have stimulated the selection, activation and integration of different affective codes such as the pictures' positive or negative valence category, or the non-/dominant hand (e.g., dominant right – positive; non-dominant left – negative); but also affective codes associated with spatial locations (e.g., right and up – positive or left and down – negative) and meaningful gestures (e.g., forward or backwards; cf. Eder, Müsseler, & Hommel, 2012). In other words, this selection, activation and integration of affective codes could be a potential mechanism integrating the affective (mis) matchings reported in the three studies (e.g., match: positive picture, right hand, and right space, resulting in positive picture' reinforcement; Study 1).

However, the effects stemming from those affective (mis) matchings (i.e., reinforcement or attenuation of the pictures' valence category) could appear in a new light when reconsidering in more detail the action by which participants manipulated the pictures. Let us take a moment to recall this question. In all studies, participants were instructed to move the pictures on the touchscreen towards an empty square. This action required first guiding the hand towards the pictures in order to touch them at their initial location on the touchscreen and then, swipe the pictures towards a target square displayed at the opposite side. Once the movement was performed, the picture disappeared and appeared again in the middle centre of the screen joint to a numerical scale in order to rate its valence. After this rating, the next trial initiated with a random presented picture at the same initial starting location.

In light of the TEC, the planned action required two movements as to events or outcomes: one from the initial point of the trial (centre of the screen where the previous picture was rated) to the presented picture. In other words, this could be a *touch – event*. The other took place when the picture was moved from the starting location on the touchscreen to the endpoint in order to reach the target-square. This could be named as the *target – event*. Although the instructions only indicated to move to picture towards the square, the rationale behind the TEC suggests that the subjects represented mentally these two events. Now, the perceptual outcome of the *touch-event* was different in every trial because the randomized presented positive or negative pictures. The perceptual outcome of the *target-event,* on the other side, could consist in the directional arm moving gesture with the picture sticking at the hand, which disappeared in every trial once the target square was reached. Therefore, according to this rationale, it seems conceivable that the effects attributed to the movement' starting point in Study 1 and 2, could be alternatively considered as part of the *touch–event*. In contrast, the effects in Study 3, would be associated with the *target – event,* or more specifically to the distance regulation effects of the arm moving gestures with the picture sticking to the hand.

Summing up, the findings of the present dissertation support a viewpoint from embodied cognition and in extension embodied interaction fields, postulating that the way we interact with an interface may affect mental states and thereby the way we mentally represent information (e.g., digital objects). In particular, according to the reported studies, it appears that swiping emotional pictures on a touchscreen monitor may influence user's affectivity as reflected in valence appraisals towards the pictures. Concretely, this influence may be positive when different affective codes match (i.e., pictures' valence category, spatial locations, and directional movement); but also negative when the codes mismatch. Moreover, this pattern of effects seems to be conditioned to the use of the dominant hand, which in this case was the right hand. However, with regard to the movements, these studies cannot disentangle whether it is the movement towards the picture (*touch – event*) or to move the stimulus away from the touch point towards a target (*target – event*), what drives the influential effects on the valence appraisals. Therefore, although the findings presented here might be of high value in Positive Technology fields, further research is needed that investigate those questions in more detail.

## 8.5. Practical implications

Against the backdrop of the present dissertation, there could be derived several practical implications. First of all, beyond the valence connotation of digital contents, the kind of interaction with the content may have affective consequences. In this case, it can be concluded that manipulating positive or negative emotional pictures using directional swipe interactions is relevant to influence users' affective responses in terms of valence appraisals. Indeed the findings may serve to answer one of the questions driving this thesis, which was the consideration of touchscreen interfaces as positive technologies from an embodied perspective. In this regard, one of the reported findings with maybe more relevance in positive technology fields could be the positive or negative reinforcement effect of the pictures' valence category. Research in positive technology often integrates emotional pictures in digital environments to stimulate users' positive or negative affective experiences (e.g., Baños et al., 2012). Accordingly, if specific interaction gestures lead to the reinforcement (or attenuation) of the affective content of a picture, this could be potentially useful to investigate the stimulation or regulation of more complex positive or negative emotional states (e.g., joy or sadness). For example, the findings suggested that actions involving swiping positive pictures with the dominant right hand from the right screen side (Study 1), from the top screen side (Study 2), and backward (Study 3) resulted in more positive appraisals. Interestingly, actions involving swiping negative pictures also with the right hand from the upper area of the screen, and backwards resulted in more negative appraisals. In addition, swiping negative pictures with the non-dominant hand from the left side of the screen indicated more negative appraisals (Study 1). It is important to remark that some of these effects must be taken cautiously due to their marginal significance (see Table 8). Nevertheless, it is also reasonable that the joint presentation of positive and negative pictures to interact with them might have also lead to rather compensation effects in the subjects' affectivity (e.g., neutral states). Accordingly, further research is needed in order to gain insight into the reinforcement effects. For example, a possible study could investigate whether presenting only positive or negative pictures to be swiped, would result in different reinforcement effects to the ones reported in the present studies. Moreover, it could be considered the use of pictures with higher affective intensity or arousal (cf. Storbeck & Clore, 2008). The pictures used in the studies here were mild regarding arousal in order to balance the affective intensity of the positive and negative pictures' valence categories. However, presenting pictures with high emotional impact might be advisable to investigate the differential influence of the interaction gestures. Also, the subjects' emotional states could be examined by filling validated instruments (e.g., questionnaires measuring positive or negative states) before and after the pictures' manipulation. Therefore, it can be concluded that the findings of this dissertation bring new opportunities to investigate emotional implications derived from the manipulation of digital contents in a touchscreen environment.

## 8.6. Strengths and limitations

As with any piece of research there exist related strengths and limitations. To begin with, strengths of the present thesis will be outlined in the following.

First, based on embodiment literature, the research presented in this dissertation gives a first insight regarding the influence of spatial touchscreen interactions (swipe gestures) on users' affective responses such as the appraisal of emotional information (IAPS pictures). This insight is important for the understanding of how to apply such interactions for purposes beyond affective appraisals. For example, as above described, research in Positive Technology (but not exclusively) could benefit from these findings to investigate novel forms of emotional stimulation in touchscreen environments.

Second, one of the most important contributions of this thesis is the approach of two embodiment research areas relatively unconnected concerning the study of affect: embodied interaction with touchscreen interfaces and experimental research in Psychology. Accordingly, the findings of this dissertation suggest that findings reported in experimental research, typically by means of monitor screens, joysticks or keyboards could be extended to a touchscreen environment. This is important considering that users are able to manipulate valence-laden contents with the hands, thus, experiencing more natural actions with the contents (e.g., Kraus, 2014; Widgor & Wixon, 2011). This is leading to:

Third, Study 1 integrated three affective dimensions (i.e., lateral space, hand dominance, and lateral movement), which effects regarding their influence on valence appraisals were very unclear (i.e., action-to-affect link). Findings in Study 2, on the other side, stimulate new questions regarding the near-hand effects in touchscreen environments. For example, one may argue that the findings reported in the three studies are modulations of the near-hand effect. In other words, having a hand in proximity to visual stimuli may lead to different visuospatial processing of information as modulated by the performed interactions. Of course, this is just a speculation, and further research should clarify this aspect. Finally, Study 3 supports findings on approach-avoidance research with the novelty of using directional touchscreen interactions instead of static arm positions to examine affective appraisals. Thereby, these findings may contribute not only to the understanding of the mental representation of valence-laden information but also on how their physical manipulation may influence a user's affective response. That is important considering the emergent body of research interested in this topic (e.g., Milhau et al, 2017; Milhau, Brouillet, Heurley, & Bruoillet, 2012).

Finally, the methodological approximation to the studies may be also considered a relevant aspect. The linear mixed models (LMM) offer the possibility to integrate more parsimoniously in the same model both, the subjects and the stimuli as random factors as an alternative to the traditional independent by-subjects and by-items analyses of variance (ANOVA). This leads in not few circumstances to a better fit of the data (e.g., Barr et al., 2013; Locker, Hoffman, & Bovaird, 2004). Indeed, some studies investigating associations between valence and space have started using this methodology too (e.g., Dudschig, de la Vega, & Kaup, 2015).

Nevertheless, the present dissertation is also limited by several factors:

First, as above discussed, the findings from the three studies could be potentially integrated into paradigms of action planning such as the Theory of Event Coding (TEC; Hommel, 2015). In light of the TEC the subjects could cognitively represent two movements, one to touch the pictures (*touch – event*) and the other to move the pictures to the target square (*target – event*). However, the present studies cannot disentangle the influence of these two movements on the subjects' valence appraisals. Therefore, it would be necessary to examine the role that these two movements play on the reported effects. Several follow-up studies could help to answer these questions. For example, concerning the *touch – event,* it could be investigated if moving the hand towards the pictures to touch them but without moving them afterwards to the target, would be sufficient to influence the appraisals. This could be studied in more detail by letting the picture disappear immediately after the touch. A further study could investigate the *target – event* effect, by placing first the interacting hand statically on the starting location of the pictures on the touchscreen. Hence, the picture, which automatically appeared below the hand would be then moved to the opposite side. Although this action is somewhat less natural when using touchscreens, it could help to clarify if the *target–event* movement is important for the effects. Thereby, all these studies could contribute to the further clarification of the mechanisms behind the influence on the valence appraisals when using a touchscreen interface.

Second, the studies lack samples of left-handed participants. This aspect would be especially important in Study 1, which is framed in the affective connotation of the hands. Accordingly, further research should clarify whether groups of left-handed participants show similar influential effects on the valence appraisal when swiping the pictures with the dominant left or the non-dominant right hand. Besides, it would be interesting to examine whether using the non-dominant hand in studies 2 and 3 will have effects on the valence appraisals as well.

Third, some of the findings must be taken cautiously. For example, although the result-pattern of the three studies fit nicely with the literature in terms of associations between affective valence, space or movement, some of the effects were marginal. It would be important to detect other factors or moderators influencing on the valence appraisals. For example, do aspects like the movement speed or length have affective consequences beyond affect detection? (cf. Gao et al., 2012)

Finally, a further limitation of the effects reported in this dissertation is that they cannot be directly generalized to other touchscreen devices with smaller dimensions, which are not based on wide arm movements as in the studies presented here. Thus, it would be highly interesting to examine whether such effects would show up when for example using other, smaller touchscreen environments, such as smartphones and tablets. Although arm movements should rather step back in such small environments, it is conceivable that the *touch–event* becomes more prevalent. If so, it would be nevertheless interesting to examine whether spatial interaction gestures would cause similar effects than in the present studies.

In addition to these considerations, some questions not targeted in this thesis but in any case of extraordinary relevance would be to investigate for example a) whether manipulating sensory aspects such as movement's velocity or distance, which have been found associated with the detection of affect, could also be influential on affect. b) Investigate connections between directional touchscreen gestures and cognitive processes such as memory (cf. Lottridge, Chignell, & Jovicic, 2011). For example, some studies have indicated that performing vertical arm movements may influence the recall of positive or negative memories (cf. Casasanto & Dijkstra, 2010). Other studies have shown, that affective connoted arm positions (flexion-extension) influence insight problem solving a creative generation (e.g., Friedman & Förster, 2002).

# Summary

The present dissertation investigated, from an embodied perspective, the potential of touchscreen interfaces as “positive technologies”. Positive Technology is a research area concerned with promoting the quality of user’s affective experiences in digital and interactive environments (e.g., Riva, 2012). Interestingly, despite touchscreens enable the manipulation of digital contents with the hands, it remains quite unclear how such bodily interaction may influence users’ affectivity. This thesis aimed to shed light on this question from research approaches framed in embodiment theory (e.g., Barsalou, 2008). Specifically, research on embodiment touchscreen interaction suggests that manipulating visual contents (e.g., images) with directional gestures (e.g., swiping) may stimulate the visuospatial processing and meaningful cognitive representations of said contents (e.g., Segal, 2011). On the other side, psychological research indicates that the mental representation and processing of emotional valence is associated with bodily dimensions of space and related directional arm movements (i.e., horizontal, vertical and sagittal; cf. Crawford, 2009). Considering the integration of these two lines of research, it was examined if and how swiping valence-laden pictures on a horizontal (Study 1), vertical (Study 2), and sagittal (Study 3) large-scale touchscreen space would influence affective responses of right-handed subjects as reflected in their valence appraisals towards the just swiped pictures.

Study 1 built upon research suggesting that experiences of motor fluency associated with hand dominance are critical to represent emotional valence in the horizontal space. Right-handers, for instance, associate the right space with positive valence due to the fluent actions of the dominant right hand. In contrast, they associate the left space with negative valence (Casasanto, 2009). Other studies suggested either affective connotations of the hands (dominant right hand-positive; non dominant left hand-negative; de la Vega et al., 2013) or

lateral arm movements (right arm rightwards and left arm leftwards both as positive fluent movements; Milhau et al., 2014). To examine the potential affective influence of such associations, subjects in Study 1 swiped the pictures on the touchscreen only with their dominant right or non-dominant left hand, either rightwards (from left-to-right sides) or leftwards (from right-to-left sides). Findings indicated: a) more positive appraisals of *positive pictures* swiped with the *right hand* from the *right* (vs. left) side, and b) more negative appraisals of *negative pictures* swiped with the *left hand* from the *left* (vs. right) side. Hence, it appeared that the affective matching between picture, hand, and movement' starting point led to the appraisals' reinforcement. Consequently, the mismatching led to the appraisals' attenuation (i.e., positive and negative pictures less positively or negatively appraised).

Interestingly, bodily patterns related to emotional states (e.g., postures of joy–upright or sadness–slumped) are also thought to ground representations of emotional valence in the vertical space (i.e., positive is UP, and negative is DOWN; Lakoff, 2014). This link is usually reflected when processing valenced stimuli displayed at up/down spaces (e.g., Meier & Robinson, 2004) or when performing upwards/downwards arm movements (e.g., Brookshire et al., 2010). Accordingly, subjects in Study 2 swiped the pictures on the touchscreen with the right hand either upwards (from bottom-to-top areas) or downwards (from top-to-bottom areas). Results revealed more positive appraisals of a) *positive pictures* swiped from the *top* (vs. bottom) area, but also b) *negative pictures* swiped from the *bottom* (vs. top) area, thus, suggesting once again an affective matching between picture and movement' starting point. Although this result-pattern might appear contradictory, former findings indicate that congruent mappings (positive-up; negative-down) are perceived as more positive compared to incongruent mappings (positive-down; negative-up; cf. Schnall & Clore, 2004). Moreover, touching the pictures directly with the hand could have highlighted that matching (near-hand effect; cf. Brucker et al. 2017), which was considered as an extension of previous research examining valence appraisals of emotional pictures after performing vertical movements on a touchscreen monitor, but where participants did not touch the pictures (Sasaki et al., 2015).

Finally, Study 3 was framed on theoretical paradigms suggesting that some arm movements may be associated with approach-avoidance motor tendencies. Concretely: a) positive stimuli elicit directional backwards arm movements (i.e., approach or decreasing distance between the self and an object), whereas negative stimuli elicit forward arm movements (i.e., avoidance or increasing distance; Freina et al., 2009); and b) static arm flexion positions lead to positive appraisals of positive stimuli (i.e., approach), whereas arm extension positions lead to *less* negative appraisals of negative stimuli (i.e., avoidance; Centerbar & Clore, 2006). Thus, to investigate whether directional arm movements could also influence appraisals of valence, subjects swiped the pictures on the touchscreen with the right hand either backwards (from a distal-to-proximal location) or forward (from a proximal-to-distal location). Results revealed more positive appraisals of a) *positive pictures* swiped *backwards* (vs. forward), and b) *negative pictures* swiped *forwards* (vs. backwards), suggesting an affective matching between pictures and the movement' meaning.

Along with a Positive Technology framework and its interest in promoting the quality of user's affective experiences, the presented studies revealed a common and valuable finding: affective matchings (or mismatchings) between pictures and spatial touchscreen interactions influenced subjects' affectivity as reflected in more positive (or negative) valence appraisals. However, this effect appeared limited to actions of the right hand since affective matchings of the non-dominant left hand led to more negative appraisals (Study 1). Future research should add to clarify such contrasting effects but also the role played by the movement' starting point (Studies 1 and 2) as compared to movements with affective meanings (Study 3).

# Zusammenfassung

Die vorliegende Dissertation untersuchte aus der Embodiment-Perspektive das Potential von Touchscreen-Interfaces als "positive Technologien". Positive Technologie ist ein Forschungsgebiet, das sich mit der Förderung der Qualität der affektiven Erfahrungen von Nutzern in digitalen und interaktiven Umgebungen befasst (z. B. Riva, 2012). Obwohl Touchscreens die Manipulation digitaler Inhalte mit den Händen ermöglichen, bleibt unklar, wie eine solche körperliche Interaktion die Affektivität der Nutzer beeinflussen kann. Diese Dissertation zielte darauf ab, diese Frage im Rahmen der Embodiment-Theorie zu erhellen (z. B. Barsalou, 2008). Genauer gesagt, legen Forschungen über die körperliche Interaktion mit Touchscreens nahe, dass die Manipulation visueller Inhalte (z. B. Bilder) mit gerichteten Gesten (z. B. Verschieben) ihre visuell-räumliche Darstellung und Verarbeitung stimulieren kann (z. B. Segal, 2011). Andererseits weisen konvergierende experimentelle Befunde darauf hin, dass die mentale Repräsentation und Verarbeitung emotionaler Valenz mit körperlichen Dimensionen des Raums und verwandten zielgerichteten Armbewegungen (d. h. horizontal, vertikal und sagittal) assoziiert ist (vgl. Crawford, 2009). Dementsprechend wurde untersucht, ob und wie das Verschieben von valenzbehafteten Bildern auf einem horizontal (Studie 1), vertikal (Studie 2) und sagittal ausgerichteten Touchscreen affektive Reaktionen von Rechtshändern hinsichtlich ihrer Bewertung von Bildvalenzen beeinflusst.

Studie 1 baute auf Untersuchungen auf, die darauf hindeuten, dass die durch die Handdominanz bestimmten Erfahrungen der motorischen Agilität entscheidend für die Repräsentation der emotionalen Valenz im horizontalen Raum sind. Rechtshänder assoziieren zum Beispiel den rechten Raum mit positiver Valenz aufgrund der leichteren Bewegungsfolge der dominanten rechten Hand. Im Gegensatz dazu assoziieren sie den linken

Raum mit negativer Valenz (Casasanto, 2009). Andere Studien schlugen entweder affektive Konnotationen der Hände (dominante rechte Hand positiv; nicht dominante linke Hand negativ; de la Vega et al., 2013) oder laterale Armbewegungen vor (die Bewegungen des rechten Arms nach rechts und des linken Arms nach links sind beide fließend und daher positiv; Milhau et al., 2014). Um den möglichen affektiven Einfluss solcher Assoziationen in dieser Dissertation zu untersuchen, verschoben Probanden Bilder auf einem Touchscreen mit ihrer dominanten rechten oder nicht dominanten linken Hand entweder nach rechts (von links nach rechts) oder nach links (von rechts nach links). Die Ergebnisse zeigten: a) positive Bilder werden noch positiver bewertet, wenn sie mit der rechten Hand von der rechten (vs. linken) Seite verschoben werden, und b) negative Bilder werden noch negativer bewertet wenn sie mit der linken Hand von der linken (vs. rechten) Seite verschoben werden. Es zeigte sich also, dass die affektive Übereinstimmung zwischen Bild, Hand und Startseite der Bewegung für die Verstärkung der Beurteilungen diente. Folglich führte die fehlende Übereinstimmung zu der Abschwächung der Beurteilungen (d. h. positive und negative Bilder wurden weniger positiv oder weniger negativ bewertet).

Interessanterweise werden körperliche Muster, die mit emotionalen Erfahrungen in Beziehung stehen (z. B. aufrecht-freudige oder gebeugt-traurige Haltung) als Grundrepräsentationen emotionaler Valenz im vertikalen Raum angesehen (d. h. positiv ist OBEN und negativ ist UNTEN; Lakoff, 2014). Diese Verbindung spiegelt sich gewöhnlich wider, wenn valenzbehaftete Stimuli in oberen / unteren Räumen angezeigt werden (z. B. Meier & Robinson, 2004) oder wenn Armbewegungen nach oben / unten ausgeführt werden (z. B. Brookshire et al., 2010). Dementsprechend wurden in Studie 2 Bilder auf dem Touchscreen nur mit der rechten Hand entweder aufwärts (von unten nach oben) oder abwärts (von oben nach unten) verschoben. Die Ergebnisse zeigten, dass sowohl a) positive

Bilder, die vom oberen (vs. unteren) Bereich als auch b) negative Bilder, die vom unteren (vs. oberen) Bereich verschoben wurden, positiver eingeschätzt wurden. Dies legt wiederum eine affektive Übereinstimmung zwischen dem Bild und dem Anfangspunkt der Bewegung nahe. Frühere Untersuchungen zeigten, dass kongruente Valenz-Bewegung-Abbildungen (positiv-aufwärts; negativ-abwärts) im Vergleich zu inkongruenten Valenz-Bewegung-Abbildungen (positiv-abwärts; negativ-aufwärts) positiver wahrgenommen werden (vgl. Schnall & Clore, 2004). In der Tat könnte das direkte Berühren der Bilder mit der Hand diese Übereinstimmung hervorheben (Near-Hand Effekt; vgl. Brucker et al. 2017). Diese affektive Übereinstimmung wurde als Erweiterung früherer Forschungsarbeiten angesehen, bei denen Valenzbewertungen von emotionalen Bildern untersucht wurden, nachdem vertikale Bewegungen auf einem Touchscreen-Monitor durchgeführt wurden, die Teilnehmer die Bilder jedoch nicht berührten (Sasaki et al., 2015).

Schließlich wurde Studie 3 im Rahmen des theoretischen approach-avoidance Ansatzes durchgeführt. Konkret werden zwei Arten von Armbewegungen betrachtet, die eine approach-avoidance Bedeutung haben können: Vowärts- und Rückwärtsbewegungen und Armbeuge- und Armsteckungsbewegungen. Positive Reize lösen eine schnellere Rückwärtsbewegung des Arms  aus, was zur Verringerung der Distanz zwischen dem Selbst und dem positiven Reiz führt (Annäherung), während negative Reize eine schnellere Vorwärtsbewegung des Arms auslösen, was zur Vergrößerung der Distanz zwischen dem Selbst und dem negativen Reiz führt (Vermeidung; Freina et al., 2009). Ist der Arm gebeugt, führt das zu positiveren Bewertungen positiver Stimuli (Annäherung), ist der Arm hingegen gestreckt, so werden negative Stimuli weniger negativ bewertet (Vermeidung; Centerbar & Clore, 2006). Um zu untersuchen, ob gerichtete Gesten auch Valenzbeurteilungen beeinflussen können, verschoben die Probanden die Bilder auf dem Touchscreen nur mit der rechten Hand entweder rückwärts (von distal nach proximal) oder vorwärts (von proximal nach distal). Die Ergebnisse zeigten positivere Einschätzungen von a) positiven Bildern, die rückwärts (vs. vorwärts) und b) negativen Bilder, die vorwärts (vs. rückwärts) verschoben wurden, was eine affektive Übereinstimmung zwischen Bildern und der Bedeutung der Bewegung nahelegt.

Im Rahmen der Forschung zur Positiven Technologie enthüllten die vorgestellten Studien einen hoch Interessant Befund: Affektive Übereinstimmungen zwischen Bildern und räumlichen Touchscreen-Interaktionen beeinflussten die Affektivität der Probanden, was sich in den noch positiveren Valenzbewertungen von positiven Bildern widerspiegelte. Jedoch war dieser Effekt auf Handlungen der rechten Hand beschränkt, da Übereinstimmungen der nicht dominanten linken Hand zu negativeren Bewertungen führten (Studie 1). Die zukünftige Forschung sollte die Unterschiede zwischen den Effekten, die aus der Anfangsbewegung (Studie 1 und 2) und affektiv konnotierten Bewegung (Studie 3) stammen, stärker beleuchten.

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