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Does touching information on a surface tablet affect how it is evaluated?

Inga M. Bause
Irina R. Brich
Leibniz-Institut für Wissensmedien, Schleichstraße 6, 72076 Tübingen, Germany

Friedrich W. Hesse
FernUniversität Hagen, Universitätsstraße 47, 58097 Hagen, Germany

Ann-Katrin Wesslein
Universität Tübingen, Schleichstraße 4, 72076 Tübingen, Germany

Actual as well as virtual touch have been shown to increase object valuation. The current study investigated its impact on information evaluation, perceived ownership of information, and information recognition. In a preregistered experimental study 69 participants controlled the presentation of information items by touching them on the screen (n_{touch} = 36) vs. via keyboard ($n_{no\text{-}touch}$ = 33). We tested our hypotheses using both a within- (touched vs. untouched items) and a between-participant approach (touch vs. no-touch condition). Analyses did not support any of our hypotheses; bootstrapped confidence intervals for the statistical parameters narrowly enclosed zero. These results suggest that potential effects of touch-based interaction on judgments of verbal content are likely very small.

Keywords: touchscreen usage, information evaluation, perceived ownership, recognition

Corresponding Author:
Ann-Katrin Wesslein, E-mail: ann-katrin.wesslein@uni-tuebingen.de, Phone: +49 7071 2975641
Address: Universität Tübingen, Mathematisch-Naturwissenschaftliche Fakultät, Fachbereich Psychologie, Schleichstraße 4, 72076 Tübingen, Germany

Touch is a crucial sense for early development and a central part of our multimodal cognitive system (Myers, 2005; Smith & Gasser, 2005). In their early years, children mainly learn about the external world by haptically exploring it with their mouth and their hands. Also in adults, touch is an important sense to interact both with other persons and with objects, for example when feeling the texture of clothing or fruit while shopping, or feeling out something in a bag (Hoggan, 2013). There are even words for the knowledge acquired through ones' skin or ones' hands in some cultures. Yet, the role of touch has received relatively little attention in academic research (Classen, 2005).

Nowadays, we do not only use touch to interact with physical objects and other persons, but also to virtually interact with content via touch devices. Many of us interact with touch interfaces like smartphones or tablets on a daily basis – be it to communicate, to navigate, or to shop online. In the course of digitalization, touch has become a ubiquitous way to control technological devices and interacting via touch with content presented on the screen has been shown to impact how we respond to it (e.g., Brasel & Gips, 2014; Cervera-Torres, Fernández, Lachmair, & Gerjets, 2018). User interfaces hold the potential to influence how the accessed content is experienced, explored and viewed (Brasel, 2016; Rokeby, 1998). For example, the use of touchscreens affects information search and choice in online scenarios (Brasel & Gips, 2015). Marketing studies further show that virtually touching products affects consumer behavior and product valuation thereby underpinning the assumption that interfaces may affect human behavior (Brasel & Gips, 2014; Chung, 2015). Still, the available findings on the effects of touchscreen usage stem from marketing/consumer research and concentrate on how touchscreens might affect purchasing behavior and decision making with regard to specific objects (e.g., Brasel & Gips, 2014; Zhu & Meyer, 2017). Still, in everyday life many of us do not only use touch devices for online retail but also to access information. Nonetheless, little is known about how touchscreen usage affects information processing, though it has been suggested that touch interfaces might enhance susceptibility to biases and that in comparison to information encountered via indirect touch (i.e., mouse-based), information received through touchscreens might be trusted more (Brasel & Gips, 2015). In the current study, we test whether effects of touchscreen usage that have been found in marketing/product settings also apply to information items. Insights from this research could be valuable to find optimal ways to display information and to develop effective debiasing strategies.

Effects of Touch on (E)Valuation

A consistent finding in consumer research is that touch can increase the valuation of objects (e.g., Peck & Shu, 2009; Peck & Wiggins, 2006; Wolf, Arkes, & Muhanna, 2008). The term valuation describes an estimation of the worth of an object and is often expressed in monetary terms. In line with this definition, endowment ratings (see Kahneman, Knetsch, & Thaler, 1990; Thaler, 1980) have often been taken to measure the effect of touch on valuation, demonstrating that objects that had been touched received higher endowment ratings compared to objects that were explored without touching them. Similar changes in valuation are not only observed for own objects vs. other's objects (endowment effect, see (Kahneman, Knetsch, & Thaler, 1990; Thaler, 1980), but also occur when possession is anticipated or pseudo-endowment is induced (Ariely & Simonson, 2003). Both, the effects of touch and the imagination suggest that legal ownership is no precondition for the enhanced valuation of objects (Peck & Shu, 2009). Note further that own objects are typically rated more favorably than other's objects beyond their monetary value but regarding measures representing the quality of subjective experiences such as valence or importance (Beggan, 1992). Since the monetary valuations of the object of endowment are usually closely correlated with its evaluation (Carmon & Ariely, 2000), we assume that touch also positively affects the subjective evaluation of an item.

Effects of touch on (e)valuations have been attributed to the affective response evoked by the sensory feedback elicited by the act of touching (Peck & Shu, 2009; Peck & Wiggins, 2006). Affective reactions towards stimuli are often automatic and fast, and they hold the potential to influence subsequent information processing. In other words, there is a primacy of affect over cognition (Zajonc, 1980, 1984). As a result, people often consider their feelings toward an object when evaluating it, using them as heuristics for this cognitive process (affect heuristic; Finucane, Alhakami, Slovic, & Johnson, 2000). In a similar vein, the positive (or negative) affect associated with an object can influence the size of the endowment effect, a positive affective reaction increasing the valuation of the object (Brenner, Rottenstreich, Sood, & Bilgin, 2007; Finucane et al., 2000; Shu & Peck, 2011). However, not only direct touch of objects but also touch-based interaction with objects and corresponding information on technological devices has been demonstrated to enhance endowment compared to the interaction with a touchpad or mouse-controlled computer (Brasel & Gips, 2014). Since the haptic feedback does not differ depending on the surface of the "touched" objects in the latter scenarios, the actual role of immediate affective responses caused by the quality of the tactile sensory feedback during exploration via touchscreen remains an open issue. What is clear is that it is not a precondition for touch to impact valuation.

The increased valuation of own objects has been traced back to the perceived (or psychological) ownership of the object (Shu & Peck, 2011). Perceived ownership is defined as the state of mind in which people experience an object (or part of it) as "theirs" (i.e., "It is MINE!"; Pierce, Kostova, & Dirks, 2001, p. 299). Research disentangling the effects of factual and perceived ownership suggests that the endowment effect is due to the latter (Reb & Connolly, 2007), thereby underpinning the assumption that perceived ownership can have important psychological and behavioral effects (Pierce, Kostova, & Dirks, 2003). People develop feelings of ownership for a variety of targets (Pierce et al., 2001). Touching an object increases perceived ownership and some studies even suggest that physical touch is no precondition for this effect. Rather, imagining the act of touching can be sufficient (Peck, Barger, & Webb, 2013). Furthermore, the exploration and selection of products via touch interfaces has been demonstrated to induce higher levels of perceived ownership than touchpad or mouse-based exploration and selection (Brasel & Gips, 2014). Brasel and Gips (2014) conclude that the usage of touch interfaces enhances perceived ownership and endowment to the same degree as touching real products. Though ownership is often directed towards material objects, it can also be experienced for nonmaterial objects such as ideas, words, artistic creations, and other people (Pierce et al., 2003). Our possessions become part of our extended self (Belk, 1988) and (presumably as a result of self-enhancing biases) are evaluated to be more attractive and more favorable than objects which are not owned (Beggan, 1992). Choosing an object can create associations between the object and the self, and self-evaluations (which usually are rather positive) may transfer to the object

(Gawronski, Bodenhausen, & Becker, 2007). Such effects have been shown for material objects and for abstract matters like opinions and ideas (De Dreu & Van Knippenberg, 2005). Merely being associated with a list of information items sufficed to create feelings of ownership for them, which is why the authors conclude that people "quickly and effortlessly develop ownership of arguments" (De Dreu & Van Knippenberg, 2005, p. 345). In comparison to non-associated but otherwise identical arguments, "own" arguments become part of the extended self and are valued more positively as a result of self-enhancing biases (Baer & Brown, 2012; De Dreu & Van Knippenberg, 2005).

Smartphones and tablets are expected to be integrated into the extended self more easily than laptops or desktop computers. Thus, touch-based digital interaction has been assumed to increase perceived ownership more strongly than mouse-/keyboard-based interaction due to the closer link to the extended self (Brasel, 2016; Brasel & Gips, 2015; Hein, O'Donohoe, & Ryan, 2011). Moreover, touching an object "directly" on a touchscreen is a more direct metaphor of the actual action than touching something via mouse or touchpad (Brasel & Gips, 2015). Hence, it seems that not only the interface per se but more specifically the input mode plays an important role: When participants used voice control to navigate through the task, they did not incorporate the touch device into their extended self, but established it as a partner/assistant (Brasel, 2016). Thus, the directness of touch seems to be a crucial influence. Direct touch may also lead to more perceived control, which in turn should increase perceived ownership (Brasel & Gips, 2014; Pierce et al., 2003).

Considering that much of the content encountered on touch devices is verbal, it is an important research question whether touch-based digital interaction impacts perceived ownership and evaluation for verbal information like it impacts those measures for digital representations of objects. Based on the findings discussed above we hypothesize that:

1. Touch-based interaction with an information item increases perceived ownership of the information item.
2. Touch-based interaction with an information item enhances the subjective evaluation of the information item.
3. Perceived ownership moderates the relation between touch and the subjective evaluation.

Effects of Touch on Elaboration and Learning Outcomes

Touch might not only have the potential to affect the valuation of information, but also its elaboration. Drawing upon theories of embodied cognition, a recent study showed that finger tracing graphical material on a tablet can support elaboration as reflected by higher performance in transfer tasks (Agostinho et al., 2015). Information processing and learning theories assume that active involvement and deeper information processing improve memorization and that elaborating information has a larger effect on attitude formation than only reading it (e.g., Craik & Lockhart, 1972; Petty & Cacioppo, 1986; Ponce & Mayer, 2014). In line with these theoretical assumptions, empirical studies suggest that touchscreens (in comparison to mice) can result in higher engagement levels and that interactive classroom environments with tablet usage can increase student engagement and performance (Chung, 2015; Enriquez, 2010). Enabling learners to interact with presented content is considered to be an important advantage of new technologies and has been shown to enhance cognitive involvement, comprehension and attitudes toward content (Ariely, 2000; Jiang, Chan, Tan, & Chua, 2010; Lustria, 2007). Note that beyond the possibility to interact, increased salience of information may increase cognitive processing and elaboration of the salient information item and thereby affect how it is evaluated and remembered (Kisielius & Sternthal, 1984). We assume that touching content increases its salience and thereby influences cognitive processing. According to the cognitive theory of multimedia learning the cognitive processes involved when encountering information determine the learning outcome and paying attention to relevant information (process of selecting) improves memorization (Mayer, 2009; Ponce & Mayer, 2014). Although the process of selecting is not considered to lead to such deep elaboration as the processes of organizing and integrating, it increases performance in rote memory tests in comparison to reading only (Ponce & Mayer, 2014).

Based on these potential effects of touch, we additionally derived the following research question:

> Does (touch-based) interaction enhance the depth of information processing / representation of an information item in memory?

Current Study

Building on the findings that touch-based interaction with virtual content can increase the valuation of objects, that perceived ownership is a mechanism underpinning this effect (Brasel & Gips, 2014), and that ownership can be experienced for nonmaterial objects like information items (De Dreu & Van Knippenberg, 2005), the current study investigated the effects of "touching" information items on a surface tablet. In our experiment we addressed the open issue how touch-based interaction via touch interfaces affects perceived ownership and evaluation of information items, compared to a keyboard-based interaction. We designed an experiment during which participants read different information items with varied interaction requirements (yes vs. no, within participant) and with different interaction modes (touch vs. keyboard, between participant). Subsequently, participants performed a recognition test and stated their perceived ownership and evaluations of each information item.

As indicated above, the current study aimed to answer our research questions using different approaches. The first approach focused on the comparison of judgments of information items that had been touched vs. had not been touched. This within-participant design holds the potential to reveal effects of touch beyond individual characteristics. The second approach focused on the comparison of touch-based interaction (touch condition) and non-touch-based, keyboard-interaction (no-touch condition). This between-participant comparison holds the potential to reveal specific effects of touch-based interactions above and beyond general effects of interacting with information items. Summing up, our approach to gain first insights into the effects of touch on information processing was to compare information evaluation, perceived ownership, and recognition performance both within participants (interaction vs. no-interaction) and between participants (touch vs. no-touch). The complete experimental procedure including the hypothesis, exclusion rules, power analysis, and analysis script have been preregistered (https://osf.io/xdpvh/?view_only=b7da8fd06fb543c5b67658f94d07ca26, Open Science Framework).

Building on the findings discussed above, we expected perceived ownership and information evaluation to increase for information items that had been touched compared to those that had only been read (within participants, H 1.1 & H 2.1) or keyboard interaction (between participants, H 1.2 & H 2.2). Furthermore, we assumed that perceived ownership predicts the evaluation of information and that this effect is stronger for touch interaction than for no interaction (within participants, H 3.1) or keyboard interaction (between participants, H 3.2). In addition, we assumed that recognition performance would be better for items that have been interacted with, especially via touch (H 4).

Method

Based on the experimental environment IWM-Study 2.0 (Klemke, 2017), our study was programmed using html / java script (Überall & Klemke, 2018) and ran in a browser on a tablet (Microsoft Surface Pro).

Participants

We ran a priori power analyses using GPower (Faul, Erdfelder, Lang, & Buchner, 2007) and using the package pwr within the statistic software R (version 3.3.2, R Core Team, 2017) in order to determine the required sample size. Since power analyses for linear mixed models (LMMs) and generalized linear mixed models (GLMMs) using GPower was not possible, we designed a power simulation allowing us to determine the necessary sample size in R. Where possible, we report results from both GPower and the R script (see https://osf.io/xdpvh/?view_only=b7da8fd06fb543c5b67658f94d07ca26) in Table 1. To the best of our knowledge, this is the first study to investigate the role of touch for perceived ownership and evaluation of information and neither effect sizes nor standard deviations were available from studies investigating perceived ownership in other contexts (e.g., Brasel & Gips, 2014; Peck & Shu, 2009; Pierce et al., 2001). Therefore, we based our power analyses on the expectation of medium-sized effects, with a desired power of .80.

Table 1. *Results of a priori power analyses*

Hypothesis	Analysis	α-level	Effect size	Power (1 – β)	*N* (GPower)	*N* (pwr, R)
H 1.1 & H 2.1	Paired *t*-test	.05	d_z =.5	.8	27	34
H 3.1	LMM	.05		.91		35
H 1.2 & H 2.2	Independent *t*-test	.05	*d* =.5	.8	102	128
H 3.2	LMM	.05	f^2 =.25	.8		32
H 4	GLMM	.05		.11		70

Taking together the results from all power analyses and considering the available resources, we chose a sample size of $N = 70$. The final sample consisted of German natives, mostly university students from different fields of study who were contacted via an online recruiting system at our institution. In total, 86 participants completed the study in the laboratory and received a monetary compensation (4 €) and chocolate for their participation. Since it was important for our manipulations that participants fulfilled both tasks during the first phase, participants who failed to respond to information items when indicated more than once ($n = 12$), who failed to react to non-words more than 5 times ($n = 8$), or who performed below guessing rate in the recognition test ($n = 1$) were excluded from analysis as determined in the preregistration. Since some participants failed both tasks, a total of 17 participants had to be excluded, leaving us with a final sample of 69 students ($n_{touch} = 36$, $n_{no\text{-}touch} = 33$; (48 female; 1 missing value) aged 18 to 29 ($mdn = 22$, two incomplete values for age were replaced with the mean age).

Material

In our study, participants were presented with information items describing personality traits as well as behaviors; some of these items served as target items, others as distractor items. The content of the information items was arbitrary for task performance, important was that information items could be evaluated with regard to their valence and relevance in the given scenario.

To select the information items for our study, we pretested a pool of 87 items in an online study ($N = 28$). Of these items, 36 were adapted from personality scales like the HEXACO inventory (Ashton & Lee, 2009) or the German version of the Arnett Inventory of Sensation Seeking (AISS-d; Roth & Mayerhofer, 2014), and described habits or personality traits considered unimportant in a professional context (e.g. “Enjoys the beauty of nature”, “Does not like spicy food”). The other items were selected from Bause, Brich, Wesslein and Hesse (2018), and described habits or personality traits that were rated to be important in a professional context. Further data regarding the valence of those items is available from the pretest reported in Bause et al. (2018).

In the pretest for the current study, all 87 information items were rated with regard to their relevance on a scale from 1 to 6 (1 = not at all relevant, 6 = very relevant). The 36 items expected to be unimportant in a professional context received low average ratings in relevance. Out of those items, we selected the 20 items with the lowest relevance scores ($M_{relevance} < 3$) for usage as distractor items in the planned study. We then selected the 10 most relevant positive items ($M_{relevance} > 5$) and the 10 most relevant negative items ($M_{relevance} > 3.9$) that could be parallelized with regard to their mean relevancy rating and their content. To determine the valence of the items we used the ratings from Bause et al. (2018) that reached from 1 (negative) to 7 (positive). From these items we created 5 parallelized positive ($M_{valence} = 6.51$, e.g. “Cannot be disturbed even under pressure” & “Stays on top of things, even in difficult situations”) and 5 parallelized negative information pairs ($M_{valence} = 2.1$, e.g. “Tends to shy away from conflict”, “Tends to be a bit too yielding”). In total, the participants in the current study were presented with 40 information items (20 relevant information items and 20 distractors) in a randomized order.

Procedure & Task

After reading and signing the informed consent, participants received all further instructions on a tablet. For participants in the touch condition the input mode was the touch screen, for participants in the no-touch condition an external keyboard with touchpad was connected to the tablet.

During the first phase of the study, participants read information items that were presented on virtual cards and uniformly moved across the screen from the bottom to the top. Before starting the first phase, participants read the instructions for two tasks and indicated whether they understood them.

One task (non-word task) was to read the information items carefully, and to search for non-words. If an information item contained a non-word, participants were asked to tap a button on the screen (touch-condition) / press a certain key (no-touch condition) — but only after the information card reached the upper half of the screen. For this task, we selected 20 pseudo-words (words that adhere to phonetic rules of a language but do not exist; Blanken, Döppler, & Schlenk, 1999) and randomly placed one of those items among the last 3 words of each distractor item (e.g., "Enjoys the beauty of kleer nature"). The non-word task was included to assure that participants read all information items and to make the touch manipulation less salient.

The other task (frame change task) focused on the design of the information cards. As soon as a card was completely visible on the screen, a frame appeared around the information. If the frame constituted of dashed lines, participants had to "transform" them into regular solid lines by touching the information card (touch condition) / by pressing a key (no-touch condition) for at least 2 seconds. As an effect of the participant's action, the design changed gradually. Participants had to change a dashed frame before the information item entered the upper half of the screen. One of the parallelized sets derived from the pretest was framed with dashed lines, thus each participant had to touch 5 positive and 5 negative information items throughout the frame change task.

During the second phase of the study, participants were presented with the 20 relevant information items from the first phase and with 20 new distractors items in random order. Participants were asked to state for each item whether it was new or already known from the first phase. For the relevant information items from the first phase, they were (b) asked for their ratings regarding ownership and (c) for their evaluation of the information. Finally, participants indicated for each of the 20 relevant information items to which degree it applied to them personally on a rating scale, rated their familiarity with touch devices and filled out the items of the need for touch scale. Further they answered a suspicion check and some demographic questions. Participants received their compensation and an anonymous code for data retraction.

Design

Our independent variables were directness of touch and level of interaction. Directness of touch was operationalized via the input mode participants used, resulting in two conditions: the touch-condition, with direct and touch-based input on the tablet screen, and the no-touch condition, with indirect and mediated input via a keyboard attached to the tablet. There were two levels of interaction operationalized through the frame change task (see Task & Procedure for details): information items either had to be interacted with (interaction) or they only had to be read (no interaction).

This resulted in a mixed factorial design: 2 (directness of touch: touch condition vs. no touch condition, between participants) × 2 (interaction: interaction vs. no interaction, within participants).

Our dependent variables were perceived ownership of information, evaluation of information and recognition performance (for the German version of the items see Appendix). Perceived ownership of information was measured with ratings on a scale from 1 to 6 (1 = do not agree at all, 6 = completely agree) for three items (e.g. "This is my information") that were adapted from previous research (Baer & Brown, 2012; Peck & Shu, 2009; Van Dyne & Pierce, 2004).[1] For the evaluation of information, participants rated the information item ("In a professional context, I find this information …") on a scale from 1 to 6 with regard to valence (1 = very negative, 6 = very positive) and relevance (1 = not at all relevant, 6 = very relevant). For the recognition participants stated whether or not they knew the information item from the first phase of the study ("This information item is…" a) completely new, b) already known), performance was measured as dichotomous variable (correct vs. incorrect).

Since the information items used in this study describe personality characteristics and behaviors, we included personal identification with the information as potential covariate. Participants rated how much an information item applied to them personally on a scale from 1 to 6 (1 = not at all, 6 = completely). Further, as touching information might differentially influence individuals depending on their need for touch (NFT), we measured this with the German version of the NFT scale (Nuszbaum, Voss, Klauer, & Betsch, 2010) in order to include it as an additional covariate (Peck & Childers, 2003a, 2003b; Shu & Peck, 2011).

Analysis & Results

All analyses were conducted using the statistic software R (version 3.3.2, R Core Team 2017); the α-level was set to be .05 for all analyses. We first report the results from our analyses from the within-participant approach (H 1.1, H 2.1, H 3.1), then those report the results regarding the between-participant approach (H 1.2, H 2.2, H 3.2). Last, we report results from the exploratory analysis of recognition performance (H 4)[2] and additional exploratory analyses including need for touch, personal identification, and familiarity as covariates.

Power Considerations

We acknowledge that given $N = 69$, the achieved power might be insufficient to detect effects in the between-participant comparisons. Hence, the focus is on the within-

1 Note that we had originally planned to employ six items (see preregistration), as there is no established German scale for perceived ownership. However, during piloting the experiment participants repeatedly reported frustration and fixed answer patterns because they could not differentiate between the items. Hence, we shortened our six item scale and used only three items.

2 In the preregistration we planned an additional analysis (see preregistration H 4.1). However, this analysis was inadmissible because the independence of the sample was violated. Therefore, we only report the second preregistered analysis.

participant comparison, where our sample size can be considered appropriate to detect medium-sized effects of touch on perceived ownership and subjective evaluation as well as to reveal the expected effect of perceived ownership on subjective evaluation.

Note that power is especially low for the analysis of H 4 (achieved power = .11). However, the simulation revealed that even with N = 200 the power would remain low (power = .26). This is due to both the complexity of the model and the expected small effect-size for this comparison. Thus, the informative power of this analysis is very limited and it can only be treated as an exploratory try.

Within-Participant Approach

Aiming to investigate potential effects of touch on information evaluation, perceived ownership and recognition, only data from the touch-condition was considered within the following analyses.

Hypotheses H 1.1 and H 2.1 were tested in separate one-tailed paired t-tests, analyzing whether touching information (touched items vs. untouched items) impacted perceived ownership of information (H 1.1) or information evaluation (H 2.1), respectively. Analyses revealed no difference in perceived ownership for touched items compared to items that were only read, $t(35) = 0.69$, $p = .248$, $d = 0.11$. There was also no difference in information evaluation for touched compared to untouched items, $t(35) = -1.31$, $p = .901$, $d = 0.22$. Thus, the data neither support H 1.1 nor H 2.1.

In order to test whether perceived ownership predicts the evaluation of information and whether this effect is stronger for touch interaction than for no interaction (H 3.1), LMMs were fitted to the data to predict information evaluation. The first model considered perceived ownership as a predictor variable, and allowed a random intercept for participant. For the second model, touch of information (touched vs. untouched) was added as a predictor to the first model. For the third model, an interaction term (touch × perceived ownership) was added. We conducted model comparisons to test if the model fits improved significantly. The model containing the predictor touch of information with random intercepts for participants, AIC = 2351.7, $\chi^2(1) = 0.34$, $p = .559$, did not show a higher goodness of fit than the model only containing perceived ownership as predictor (AIC = 2350.0). Adding the interaction of touch and perceived ownership also failed to improve the goodness of fit, AIC = 2353.6, $\chi^2(1) = 0.03$, $p = .854$. There is no support for H 3.1.

Between-Participant Approach

A between-participant comparison provides further insights on whether direct, touch-based interaction (touch condition) influenced our dependent variables differently from indirect interaction (no-touch condition). Only ratings of and recognition performance with regards to items with which participants had actively interacted (but not those which they had only passively read) were included in the analyses.

Both hypotheses H 1.2 and H 2.2 were tested in separate one-tailed t-tests for independent samples, analyzing whether touch, as compared to an indirect interaction mode (touch vs. no-touch condition), had a larger impact on perceived ownership of information

(H 1.2) or information evaluation (H 2.2). Analysis neither revealed a difference between conditions for perceived ownership, $t(47.67) = 0.79$, $p = .215$, $d = 0.18$, nor for information evaluation, $t(66.91) = 1.54$, $p = .064$, $d = 0.37$, supporting neither H 1.2 nor H 2.2.

In order to test whether perceived ownership predicts the evaluation of information and whether this effect is stronger for direct touch interaction than for indirect interaction via keyboard (H 3.2), a linear model was fitted to the data in order to predict information evaluation. In the first linear model, information evaluation was predicted by perceived ownership. In the second model, the predictor touch (condition: touch vs. no-touch) was added to the first model. For the third model, the interaction term (touch × perceived ownership) was added to the second model. We conducted model comparisons to test if the model fits improved significantly. The model containing the predictor condition, $F(1, 1376) = 1.21$, $p = .272$, did not show a better fit than the model only containing perceived ownership as predictor. Adding the interaction of condition and perceived ownership also failed to improve the goodness of fit, $F(1, 1375) = 1.01$, $p = .316$. H 3.2 was not supported.[3]

Exploratory Approach for Recognition Performance

For our exploratory investigation of the effects of touch of information on recognition performance (H 4), GLMMs were fitted to predict recognition performance. The first model considered interaction (interaction vs. no interaction) as a predictor variable, and included a random participant intercept. For the second model, condition (touch vs. no-touch) was added as a predictor to the first model. For the third model, an interaction term (interaction × condition) was added. We conducted model comparisons to test if the model fits improved significantly.

The model containing the predictor condition, AIC = 1799.1, $\chi^2(1) = 0.38$, $p = .535$, did not show a higher goodness of fit than the model only containing interaction as predictor (AIC = 1797.5). Adding the interaction of touch and perceived ownership also failed to improve the goodness of fit, AIC = 1801.0, $\chi^2(1) = 0.11$, $p = .745$. The data did not support H 4.

A Closer Look at the Confidence Intervals

To allow a more meaningful interpretation of our results we looked at the confidence intervals for our analyses. Confidence intervals narrowly enclosing zero suggest that substantial and relevant effects of touch in our scenario are unlikely.

As can be seen in Table 2, the lower and upper limits of the 95 % confidence intervals for all calculated *t*-tests not only enclosed zero, but were also very small, especially for the within-participant comparisons. Thus, even with more power it is unlikely to find differences of means that are of substantial interest.

The bootstrapped confidence intervals for the parameters of the LMMs are depicted in Figure 1. For perceived ownership (abbreviated "po" in Figures 1-3) the 95 % confidence interval is larger than zero, indicating a positive influence of perceived ownership on information evaluation. For the parameter touch (whether an item had been touched or not)

3 Including our covariates (personal identification, NFT) in exploratory analyses did not reveal any effects, which is why we do not report them here.

Table 2. *95% confidence intervals for t-tests (calculated with two-sided t-tests)*

Within participants					
H 1.1 & H 2.1	$M_{touched}$	$M_{untouched}$	$M_{difference}$	lower limit (95% CI)	upper limit (95% CI)
Perceived ownership	3.723	3.766	0.042	- 0.083	0.168
Information evaluation	4.427	4.384	-0.042	- 0.108	0.023
Between participants					
H 1.2 & H 2.2	M_{touch}	$M_{no\text{-}touch}$	$M_{difference}$	lower limit (95% CI)	upper limit (95% CI)
Perceived ownership	3.745	3.890	0.145	- 0.221	0.512
Information evaluation	4.405	4.516	0.111	- 0.032	0.254

and the interaction of perceived ownership and touch (po:touch) the confidence intervals enclosed zero. The confidence interval for the interaction effect is especially small (lower limit = –0.101, upper limit = 0.122). This raises the question if a substantial interaction effect of interest can be found even with more power.

The bootstrapped confidence intervals for the parameters of the linear models are depicted in Figure 2. For perceived ownership the 95 % confidence interval was larger than zero, showing a positive effect of perceived ownership on information evaluation. The 95 % confidence intervals for the parameters condition (touch vs. no-touch) and interaction of perceived ownership and condition (po:condition) enclosed zero. The confidence interval for the interaction effect is very small (lower limit = –0.141, upper limit = 0.045). Thus, even with more power, it is unlikely to find a substantial interaction effect.

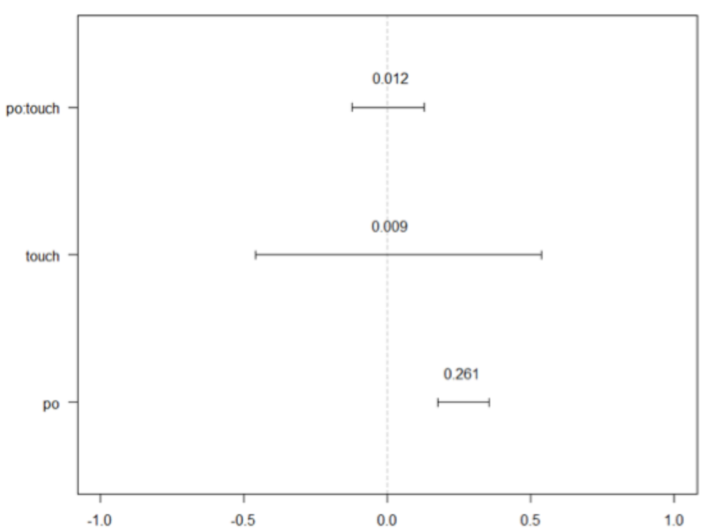

Figure 1. *Bootstrapped 95% confidence intervals for parameters of LMMs (H 3.1), po = perceived ownership, touch = item touched vs. item untouched*

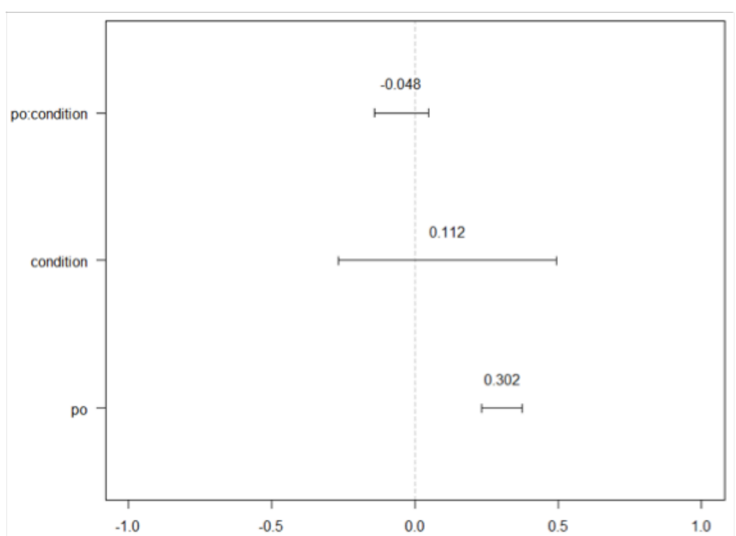

Figure 2. *Bootstrapped 95% confidence intervals for parameters of linear models (H3.2), po = perceived ownership, condition = touch vs. no-touch*

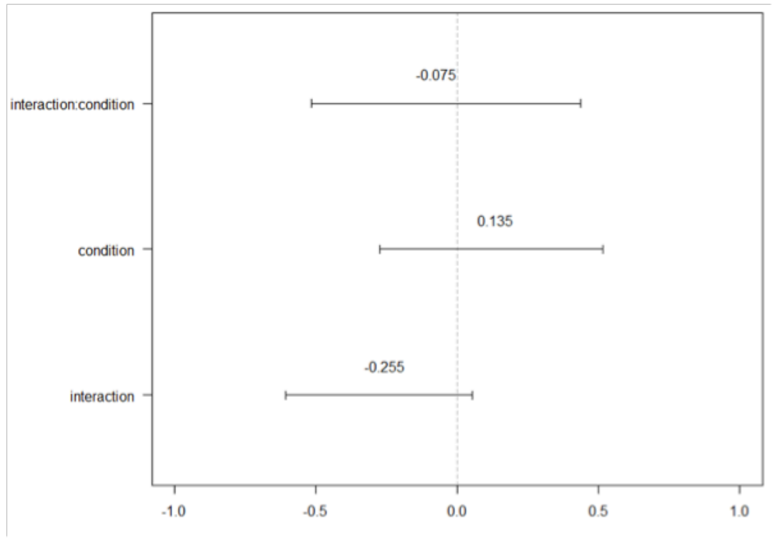

Figure 3. *Bootstrapped 95% confidence intervals for parameters of GLMMs (H 4), interaction = interaction with item (yes vs. no), condition = touch vs. no-touch*

The bootstrapped confidence intervals for the parameters of the GLMMs are depicted in Figure 3. For interaction (interaction vs. no interaction with information item), condition (touch vs. no-touch) and the interaction term (interaction:condition) the 95 % confidence intervals enclosed zero, underpinning that there were no effects of either factor or the interaction of both factors on recognition performance. The confidence interval for the interaction effect (lower limit = −0.566, upper limit = 0.323) raises the question if an interaction effect of interest can be found even with more power.

Discussion

Prior research points out the importance of touch as part of our multimodal system (Smith & Gasser, 2005) and suggests that touching objects results in higher perceived ownership and higher valuations (e.g., Peck & Shu, 2009). Similar effects have also been demonstrated for virtual touch of pictures of objects (Brasel & Gips, 2014). In the current research, we investigated the effects of touching information items on a surface tablet on perceived ownership of information, information evaluation and recognition performance. We analyzed these variables depending on (1) whether an information item had previously been interacted with (i.e., it had been touched) or not (touch condition only, within participants) as well as (2) depending on whether it was interacted with via touch or via keyboard (between participants). Our assumption was that directly touching information on a touch interface would result in higher values for our dependent variables. However, none of our hypotheses was supported: We observed no significant effects of touch or interaction with regard to perceived ownership of information, information evaluation or recognition performance. A closer look at the confidence intervals narrowly enclosing zero substantiated how unlikely it is that there is a relevant effect of touch in our scenario. These results suggest that effects of touch-based interaction on the valuation of products in a consumer-behavior setting (Brasel & Gips, 2014) do not generalize to verbal information items. Thus, the exact circumstances under which touchscreen usage affects human behavior and cognition need to be further explored. In the following, we consider differences of the current study in comparison to prior research and discuss possible explanations with regard to perceived ownership, evaluation and elaboration of information.

In two laboratory studies varying the interface/input mode participants had to choose one product out of a product selection (e.g., college sweatshirts, city tours, tents) in an online shopping scenario (Brasel & Gips, 2014). Touchscreen usage resulted in higher perceived ownership for chosen products in comparison to touchpads or mice. Higher perceived ownership in turn increased the valuation of the chosen products. A closer look reveals that perceived ownership was especially enhanced by touch when haptic information was relevant for the to-be-evaluated product (e.g., a sweatshirt), compared to when it was not (e.g., a sightseeing tour). Thus, the effects of touch on more abstract concepts like information items might be smaller than on concrete objects in online retail scenarios. Accordingly, our study might not have had sufficient power to find effects because we calculated power for small to medium-sized effects (see a priori power analyses). Thus, to conclude that touching information on mobile touch interfaces does not affect how it is evaluated further studies with more power would be necessary. Since this would mean recruiting sample sizes of $N > 200$, it should also be contemplated whether such small effects are considered meaningful enough to be investigated with such expenditure.

A study using a similar set up to the present research also compared the use of tablets to the use of tablets with a mouse/touchpad connected (Brasel & Gips, 2015). This has the advantage that "indirect" (touchpad) and "direct" (touchscreen) touch can be compared for the same device without differences in screen size, resolution or processing power. In the mentioned study, effects of direct-touch were reported. Importantly, when participants used the mouse, the tablet was placed in a stand whereas it was held in the hand in the touch condition. In the present setting, the tablet was placed in a stand in both the touch and the no-touch condition. Further research is needed to disentangle the effects of touch interaction vs. mouse/keyboard interaction on information evaluation and perceived ownership from those of holding the device in one's hand.

In other studies on effects of touch on perceived ownership and valuation, participants were explicitly asked to touch an object (e.g., a mug) or <u>not</u> to touch it (Peck & Shu, 2009). This might be different than comparing touch interaction to indirect interaction, because seeing an object and not being allowed to touch it might actually decrease the level of control participants experience and being able to control an object increases perceived ownership (Pierce et al., 2003). In the current study participants were not explicitly forbidden to interact with the content and could exert a certain level of control through the frame changing task in both the touch and no touch condition. In other words, the current setting might have induced a low level of experienced control because the information items continuously appeared and moved across the screen and participants had to react to it. For perceived ownership to emerge the target should at least be visible and attractive, receive interest or attention and be experienced by the individual (Pierce et al., 2003). Although the information items in our scenario were visible, received attention and were experienced, information items in general might not elicit the same feelings of ownership as objects. One possibility to increase perceived ownership for information might be to let participants create information items or part of them (Baer & Brown, 2012). For example, by changing the information instead of the frame around it. However, this kind of manipulation would make it difficult to distinguish between the influence of touch and the influence of creating something. Future studies should attempt to disentangle these effects and investigate whether effects of touch might be larger for "own" content than for neutral, assigned content. In general, note that we observed an effect of perceived ownership on the evaluation of information. Items that received higher ratings of perceived ownership were evaluated more positively. This is in line with previous research (e.g., Baer & Brown, 2012; Beggan, 1992; De Dreu & Van Knippenberg, 2005; Pierce et al., 2003; Shu & Peck, 2011).

Studies suggest that the length of ownership and, in absence of legal ownership, the duration of touch influences feelings of ownership and endowment (Wolf et al., 2008). Participants who had more time to physically examine and touch a mug were willing to pay more in a following auction. Although exposure (touch) times were relatively short (10. vs. 30 seconds) they were considerably longer than in our experiments (2 seconds). Maybe increasing the time participants have to touch a virtual information item could increase the feelings of ownership. However, it is unclear whether the duration of exposure effect also holds for digitally encountered objects. Since simply clicking was enough to elicit perceived ownership (Brasel & Gips, 2014) and even just thinking about an option created feelings of ownership (Carmon, Wertenbroch, & Zeelenberg, 2003), it seems unlikely that the lack of influence of touch in our experiment is simply due to the short duration of touch. In addition, touching information on a touchscreen for such a prolonged time is unusual and seems rather artificial. Thus, even if a longer duration would reveal effects of touch, their relevance in more realistic settings would be questionable.

Gawronski, Bodenhausen, and Becker (2007) distinguish two processes that underlie evaluations, namely associative processes and propositional processes. While associative processes influence implicit evaluations, propositional processes result in explicit evaluations. Evaluations that result from associative processes (also described as affective reactions) are automatic and independent of whether a person believes them to be true or not. Propositional processes (also described as evaluative judgments) involve inferences from available information and consider whether a proposition is believed to be true or not. Implicit and explicit evaluations do not have to be consistent and are worth to be distinguished (see Wilson, Lindsey, & Schooler, 2000). However, it is assumed that evaluative judgments are based on automatic affective reactions as long as propositional reasoning does not invalidate the implications (Gawronski & Bodenhausen, 2006). For example, a negative reaction to a foreign looking person is not used for evaluative judgment when propositional reasoning reveals the negative association to be false. In our case, it might be that touching an information item changed the implicit evaluation via the association to the self, but not the propositional processes. Since we measured the explicit evaluation, it might be that we did not find an effect because propositional processes overruled associative processes. Future studies should include implicit evaluation measures.

We expected the interaction with information items to result in more elaboration and deeper processing, thereby increasing the retention of information. Participants correctly recognized whether they had already seen the information item in 72% of the cases, regardless of whether they had interacted with it. There was no difference in retention of information items that were read and information items that participants interacted with – be it via touch or via keyboard. Apparently neither the higher salience resulting from the divergent frame nor the higher interactivity resulted in deeper elaboration of the information. It might be that the task was simply not engaging and interactive enough, or that the interaction engaged participants in unproductive activity (Mayer, 2009). This is in line with a recent study comparing passive to active implementations of study, in which also no support for the interactivity hypothesis was found, so it was concluded that "activity per se does not necessarily cause learning" (Ponce & Mayer, 2014, p. 29). In addition, it could be that touching and changing the frame only directed the attention towards the frame instead of the information item itself. Future studies could employ highlighting or changing the information itself, in order to ensure that attention is focused on the item. However, this might bring along other confounds because text-signaling devices such as highlighting have been shown to improve retention (Lorch, 1989; Ponce & Mayer, 2014).

Our results suggest that the effects of directly touching information on touch interfaces on information evaluation and processing might be smaller than expected. Nevertheless, the discussed alternative explanations, limitations and further research opportunities point out the need to explore the circumstances under which touchscreen usage might affect information processing and evaluation. Moreover, further studies are needed to specifically compare the influence of touch on real objects, digital objects and verbal materials. We recommend that future studies should consider equivalence testing as an approach because the effects of touchscreen usage are likely to be very small (see Lakens, 2017). In this procedure the smallest effect size considered to be of interest is used to specify boundaries that allow to statistically reject the existence of a relevant effect. The current study does not allow a conclusion with regard to the existence or non-existence of touch effects on evaluation, perceived ownership and elaboration of information. It does, however, provide valuable insights by pointing out the possibility that effects of touch on verbal information items are too small to be considered of relevance and by emphasizing the need to understand the exact circumstances under which relevant effects of touch-based virtual interaction arise.

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Appendix

Measurement of Dependent Variables, German Scales

Perceived Ownership of Information

1. Das ist meine Information.
2. Ich habe das Gefühl, diese Information zu besitzen.
3. Es fällt mir schwer, diese Information als meine anzusehen.

6-stufige Skala (1 = *stimme überhaupt nicht zu*, 2 = *stimme nicht zu*, 3 = *stimme eher nicht zu*, 4 = *stimme eher zu*, 5 = *stimme zu*, 6 = *stimme voll zu*)
Items developed based on: Baer & Brown (2012); Peck & Shu (2009); Van Dyne & Pierce (2004)

Information Evaluation

Diese Information finde ich im beruflichen Kontext: 1 = *überhaupt nicht relevant*, 2 = *nicht relevant*, 3 = *eher nicht relevant*, 4 = *eher relevant*, 5 = *relevant*, 6 = *sehr relevant*
Diese Information finde ich im beruflichen Kontext: 1 = *sehr negativ*, 2 = *negativ*, 3 = *eher negativ*, 4 = *eher positiv*, 5 = *positiv*, 6 = *sehr positiv*

Need for Touch

NFT1-A: Wenn ich einkaufen gehe, muss ich alle möglichen Artikel anfassen.
NFT2-A: Es macht Spaß, alle möglichen Artikel anzufassen.
NFT3-I: Ich vertraue stärker auf Artikel, die man vor dem Kauf anfassen kann.
NFT4-I: Beim Kauf eines Artikels fühle mich wohler, wenn ich diesen vorher durch Anfassen eingehend geprüft habe.

NFT5-A: Wenn ich mich in Geschäften umsehe, ist es wichtig für mich, alle möglichen Artikel in die Hand zu nehmen.
NFT6-A(R): Es fällt mir schwer davon abzulassen, in Geschäften alle möglichen Artikel anzufassen.
NFT7-I: Wenn ich einen Artikel im Geschäft nicht anfassen kann, möchte ich diesen nur ungern kaufen.
NFT8-A: Auch wenn ich einen Artikel nicht unbedingt kaufen will, mag ich es ihn anzufassen.
NFT9-I: Beim Kauf eines Artikels fühle ich mich sicherer, wenn ich diesen zuvor anfassen konnte, weil ich dadurch etwas über die Qualität des Artikels erfahren kann.
NFT10-A: Beim Stöbern in Geschäften mag ich es einfach alle möglichen Artikel anzufassen.
NFT11-I: Um herauszufinden, ob es sich lohnt einen Artikel zu kaufen, muss man diesen angefasst haben.
NFT12-I: Es gibt eine Vielzahl von Artikeln, die ich nur kaufen würde, wenn ich sie zuvor auch in die Hand nehmen kann.
NFT13-A: Beim Einkaufen ertappe ich mich immer wieder dabei, dass ich alle möglichen Artikel anfasse.
NFT14-I(R): Ich kaufe nur selten Artikel, die ich vor dem Kauf nicht anfassen konnte.

7 stufige Skala (-3 = *trifft überhaupt nicht zu bis* +3 = *trifft völlig zu*)
R = removed items; A = autotelic scale; I = instrumental scale.
Based on: Nuszbaum, Voss, Klauer, & Betsch, 2010

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