Social Acceptability in HCI: A Survey of Methods, Measures, and Design Strategies

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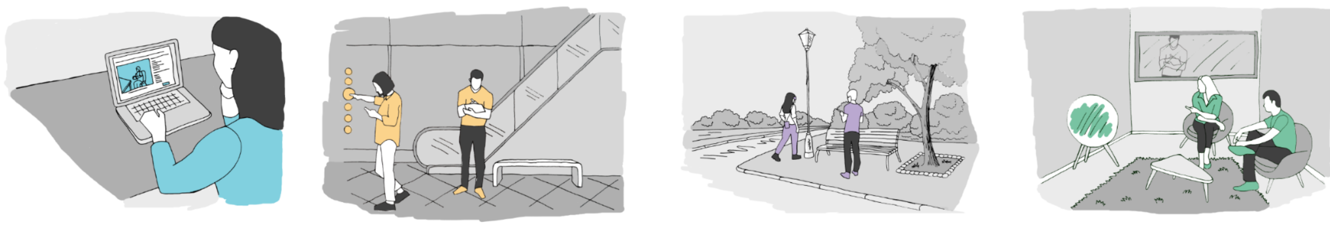

Figure 1. We analyzed current practices of researching social acceptability in HCI. Common study settings include online surveys (left), e.g., collecting ratings of video prototypes [101], and field experiments with the researcher present (mid left, mid right), e.g., in public indoor locations [1] or outdoors [68]. Only few studies simulate social context in laboratory experiments (right), e.g., using a model living room [114].

ABSTRACT
With the increasing ubiquity of personal devices, *social acceptability* of human-machine interactions has gained relevance and growing interest from the HCI community. Yet, there are no best practices or established methods for evaluating social acceptability. Design strategies for increasing social acceptability have been described and employed, but so far not been holistically appraised and evaluated. We offer a systematic literature analysis (N=69) of social acceptability in HCI and contribute a better understanding of current research practices, namely, methods employed, measures and design strategies. Our review identified an unbalanced distribution of study approaches, shortcomings in employed measures, and a lack of interweaving between empirical and artifact-creating approaches. The latter causes a discrepancy between design recommendations based on user research, and design strategies employed in artifact creation. Our survey lays the groundwork for a more nuanced evaluation of social acceptability, the development of best practices, and a future research agenda.

Author Keywords
Research methods, social acceptability, literature analysis.

CCS Concepts
•General and reference → Surveys and overviews; •Human-centered computing → HCI design and evaluation methods;

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INTRODUCTION
Our interactions with technology are increasingly happening in a social context. It may be co-located with others (e.g., spectators) or include shared interface usage. This may in turn affect our social interactions and shape group dynamics. As a result, social acceptability, as a core quality of human-machine interactions [81], has become increasingly relevant with today's interfaces and interaction paradigms. This trend falls in line with the ongoing shift in HCI towards emotions [13], experiences [39], values [14], and needs (so-called third wave HCI, c.f., Bødker [12]), as social acceptability is an aspect of technology use that is often emotionally charged and shaped by societal needs and values.

A lack of social acceptability can have a profound effect on the user's self- and external image [32], and affect the overall user experience [128], as it may include the risk of stigmatization, mis-perceptions and negative judgment through others [56, 91, 92, 111]. Consequently, there has been an increasing interest in designing socially acceptable human-machine interactions and interfaces [44, 89, 131]. Yet, the methodical knowledge on designing, and evaluating social acceptability in HCI is fragmented; evaluation methods, agreed-upon measures or best practices are sparse [57]. Similarly, design strategies for increasing an interface's social acceptability have been employed and in parts empirically verified for individual interface types, interaction paradigms, or application areas, but so far not holistically appraised and evaluated.

In this paper, we contribute to establishing a grounded and more refined view of social acceptability. We take an inventory of current practices for studying and addressing social acceptability issues in HCI by conducting a structured literature review (N=69) to answer the research question:

> **RQ:** Which methods, measures and design strategies are employed to evaluate, quantify, and influence the social acceptability of human-machine interfaces?

Synthesizing current research practices (c.f., Figure 1) allows to map established methods, criticize and compare employed measures. It allows to identify shortcomings in the way research is conducted to propose opportunities for future work.

HCI has a long tradition of survey-style reflections of research methodology [20, 34, 51, 52, 123] with the goal of exposing trends and gaps. With the growing interest and recognition in social acceptability reflected by recent ('19) work [9, 59, 108, 131, 137], it has reached the required level of maturity (c.f., Wobbrock et al. [134]) and timeliness to both warrant and require a survey perspective on employed research practices. Yet, to the best of our knowledge, our present work is the first to contribute an in-depth survey of the current perspective HCI research takes on social acceptability.

We offer the following three contributions: First, we analyze how the social acceptability of interactive systems has been evaluated in HCI. We outline and discuss methods and measures in terms of their distribution, replicability, internal, external and ecological validity. Second, we provide an overview of design strategies that have been employed to increase the social acceptability of interactive systems. In particular, we discuss to what extend they have been empirically confirmed. Third, we identify methodical gaps concerning social acceptability in HCI, and discuss challenges and opportunities to guide future research in this area.

SOCIAL ACCEPTABILITY

Albeit named as essential part of system acceptability early on [81], there are only few conceptualization attempts of social acceptability in HCI so far [57, 77, 128]. In this section, we collect explanations and descriptions from these and further prior work in HCI, and aggregate them into a working definition of social acceptability.

The APA Dictionary of Psychology [120] defines *social acceptance* as "the absence of social disapproval". This definition **by negation** is also common in HCI, where social acceptability is often defined through its absence: *"A socially acceptable wearable is most notably marked by an absence of negative reactions or judgments from others."* [49]. In an earlier work, Toney et al. define the social weight of a human-machine interaction as the *"measure of the degradation of social interaction that occurs between the user and other people caused by the use of that item of technology"* [117]. In addition, prior work describes social acceptability not only by negation, but also as a reciprocal rather than an isolated, individual experience. This duality of social acceptance is grounded in a well-established concept from sociology, Goffman's theory of impression management [32]. Following Goffman's basic premise that all public action is a performance [32], and that performances are typically staged for an audience, it seems self-evident that also human-machine interactions can involve both, *performer* and *spectator*. As an individual will strive to control and consciously shape the impression other persons will form of them, this duality of performer/spectator roles influences *if, how and where human-machine interfaces will be used*. First highlighted by Brewster et al. [16], the consideration of this duality in the study of social acceptance in HCI[1] was formalized by Montero et al. [77] who describe social acceptance using two dimensions: (a) The *user's social acceptance*, an internal effect of the interaction that will leave the user with a subjective impression, and (b) the *spectator's social acceptance*, an external effect of the user's interactions. Spectators perceive the user's interactions with the device and gain an impression of the user. This duality between user (performer) and others in their vicinity (spectators) is present throughout prior work [1, 3, 7, 30, 56, 114, 132]. Thus we understand it as central to HCI's current understanding of social acceptability. In addition, social acceptance is not a one-time decision between acceptable and unacceptable, but rather a *"user's continuous decision process that is influenced by the experiences gathered while performing"* [128]. As a decision process, social acceptance shows strong parallels to Davis' well-known and broadly used Technology Acceptance Model (TAM) [24], which describes the adoption of new technologies by individuals influenced through two main factors: perceived usefulness (PU) and perceived ease-of-use (PEOU). Although TAM knows derivatives models (e.g., UTAUT) that add subjective norms and social influence (SI) [71, 121], they only account for *positive* social influence, i.e., feedback encouraging the interaction. In contrast, social acceptance includes *both positive and negative* social judgement [49] and is thus only partially reflected in TAM/UTAUT.

We can describe the *social acceptability of a human-machine interaction* as a process consisting of (1) the user's performance and the impression it creates in terms of both the *internal effect* (c.f., user's social acceptance) and the *external effect* (c.f., spectator's social acceptance). As the user would want the interaction to be consistent with their self-image and to receive positive feedback, they will (2) evaluate their internal impression along with a higher level interpretation of the spectators' feedback. Subsequently, they will (3) adjust their interaction accordingly or cease interacting. In consequence, we can specify a working definition of a human-machine interface's social acceptability as follows.

> **Working Definition:** A human-machine interface can be considered *socially acceptable*, if its presence or the user's interactions with it are consistent with the user's self-image and external image, or alter them in a *positive* way. Human-machine interfaces that cause a *negative* change to self- and external image show a lack of *social acceptability*.

It lies in the nature of this (iterative) process that it changes over time: while the user gains more experience with the interaction, they might grow accustomed to previously unfamiliar interactions or collect diverse and controversial feedback from spectators. In addition, a user's aspirations, i.e., the public image of themselves they would like to convey, is also bound to change. Last but not least, social and cultural expectations may develop and change over time which shapes the (positive or negative) feedback conveyed by different audiences.

[1]Terms used mostly interchangeably [57], e.g., Brewster et al. [16] use *social acceptability*; Montero et al. [77] *social acceptance*.

REVIEW METHOD AND PAPER SELECTION

Informed through the approach taken by prior literature reviews in HCI [43, 90, 107], we employed a process of browsing, screening, backward-chaining, and final appraisal.

Browsing

We used the ACM Digital Library (ACM-DL) as initial outlet where we conducted a keyword search using variants of the word combinations *social acceptability* and *social acceptance*, including different grammar forms as in Figure 2. We conducted our search in Q1/2019 and limited it to publications between 2000 and 2018, which yielded 164 entries in the ACM-DL.

```
“query”: {(“social acceptability”; “social
unacceptability”; “social acceptance”; ”social
unacceptance”; “social nonacceptance”; “socially
acceptable”; “socially unacceptable”)}
“filter”: { Publication Date: (01/01/2000 TO
12/31/2018), ACM Content: DL }
```

Figure 2. Search query used for key phrase search in the ACM Full Text Collection (matches “any field”); Publication years 2000-2018.

Screening and Backward-chaining

All query results were screened according to 4 inclusion respectively exclusion criteria, namely: (1) the work is original, peer-reviewed research; i.e., we excluded workshop proposals, newsletter, commentaries and summaries, as well as student theses. The work (2a) contains a formal or informal evaluation or measurement of social acceptability, or (2b) names social acceptability as design goal for a presented prototype or interface, or (2c) names design recommendations for socially acceptable interfaces. (3) the work covers the social acceptability (from user and spectator perspective) of a user's interaction with a system, interface or technology; i.e., we excluded work on virtual agents or (humanoid) robots. We explicitly did not target autonomous systems that aim to achieve sociable or socially acceptable behavior by adopting or mimicking (human) behavior. These include (humanoid) robots [116] or autonomous cars [21]. For a survey in the context of social robotics, we refer to Savela et al. [106].

Screening was conducted by the 1st and 2nd author separately based on the aforementioned criteria, paper titles and abstracts and by skimming the full texts. Their 88% accordance indicates a substantial inter-rater agreement [62] with $\kappa = .72$ (95% CI, .60 *to* .84). Discrepancies were discussed on a per-paper basis, resulting in an initial set of 47 papers.

To account for publication venues not included in the ACM-DL, we employed backward-chaining, i.e., we additionally evaluated all papers referenced by the works selected in the previous step against the inclusion and exclusion criteria (snowballing principle). This yielded 23 additional papers.

Final Appraisal

For final appraisal we considered again all resulting full texts. At this stage, we excluded one paper ([82]) that contained social acceptability in the abstract, but its remainder focused on the TAM factors perceived ease-of-use, perceived usefulness without addressing (positive or negative) social influence. The final set (N=69) included conference papers of varying length (n=55) and extended abstracts (n=10) as well as journal articles (n=4). A majority of papers was published at CHI (n=20), followed by MobileHCI (n=10), UIST and TEI (n=4 each), and ICMI, and ASSETS (n=3 each).

Analysis and Synthesis

We identified 46 (67%) papers that presented a formal or informal evaluation or measurement of social acceptability (2a). 52 papers suggested or employed design strategies to increase the social acceptability of an interaction or interface (2b). 29 papers contained both, user studies and design strategies (see Figure 3 for an overview). Only 7 papers named concrete design recommendations (2c).

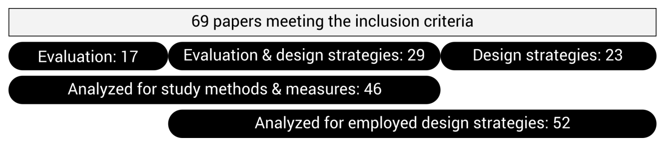

Figure 3. We analyzed the overall 69 papers for methods and measures (46 papers) and for design strategies (52 papers).

We employed a strategy of clustering, and additional closed coding for methods and measures, respectively open coding for design strategies. We furthermore grouped all papers according to their research contribution based on [134], and study type as defined and discussed by Kjeldskov et al. [51, 52]. For papers that contained multiple subsequent studies or experiments, we only considered those that evaluated social acceptability. Mixed method approaches or combinations are counted for each study type.

In the following, we outline the results of this analysis, specifically, in terms if methods and measures (46 papers), and design strategies (52 papers). We name and discuss benefits and disadvantages of each method, particularly with regard to ecological, internal, and external validity, as well as reliability, and applicability. We highlight that each of the analyzed methods and study designs, despite having both advantages and disadvantages, provides a valuable contribution that helps to better understand social acceptability issues with human-machine interfaces. Thus, instead of singling out flaws of individual studies, or designs, we aim for a more holistic view of how social acceptability is addressed in current HCI research. By mapping methods and design strategies this overview paper provides a basis for identifying best practices.

In particular, we point out research gaps, both in terms of methodical contributions and study methods, and under-evaluated aspects of socially (un)acceptable designs, that will allow for a more nuanced view of study methods, and create a valuable basis for future research.

Limitations

The use of the ACM-DL as initial outlet may induce certain limitations. Querying only titles and abstracts yielded only 20 publications (all included in the analysis). Thus, we expanded the scope of the query to include further fields. As also noted by Pohl et al. [90] a query in the ACM-DL yields different results when applied to "`full-text`" respectively "`any field`". While we used the latter, similar to Pohl et al. [90], we also did find no apparent evidence for a systematic bias introduced through this procedure. However, persistence of meta-data is indeed a common issue with digital libraries [73]. In consequence, a search query can yield slightly divergent results depending on the time of search; for instance due to adaptation of retrieval and ranking algorithms in the digital libraries backend. For this reason, we employed backward-chaining to rule out systematic bias introduced through the ACM-DL's organization of meta-data.

METHODS & MEASURES

In this section, we only consider the 46 (68%) papers that contained a formal or informal evaluation of social acceptability, all of which empirical, i.e., user studies. Of this subset of 46, 35 papers evaluated the user's perspective, 17 the spectator's perspective; 14 included both, the user's and the spectator's perspective. Only 8 papers evaluated general views, neither explicitly user or observer. In the following, we detail on study settings, procedures, and employed scales and measures.

Staging Experiments: Online, Lab & Field

As social context is typically mediated through location, we first report on study settings and locations.

Surveys

Social acceptability largely depends on subjective perception and individual opinions. Thus, it is not surprising that a popular way to evaluate social acceptability are surveys (n=16), of which a large number were conducted online (n=11 online, n=5 in the lab). We found a large variation in the number of survey participants (M=254, SD=382): from 20 in [33] to 1200 in [92]. Only a small number of the analyzed surveys were purely textual questionnaires [19, 33, 78, 80, 86]. The majority of both surveys conducted online, and surveys administered on-site, use videos (n=7), animations (n=2) or still imagery (n=3) to present the (remote) participant with a fictive scenario in which the interface would be used. Except in [29] where remote participants were asked to try out gestural interaction as shown in the videos contained in the online questionnaire, participants in the analyzed studies were not explicitly encouraged to interact. In consequence, imagining themselves in the user role, e.g., perfoming unfamiliar interactions, often required guesswork by the participants. Although less severe, this imaginary component, which requires the participants to put themselves into a situation potentially never experienced before, might also affect questionnaires completed from a bystander perspective. While this lack of firsthand usage experiences has been criticized, e.g., by Ahlström et al. [1], there are indicators that (crowdsourced) surveys can still be a viable alternative to laboratory experiments when evaluating social acceptability [4]. In addition, surveys administered online may also allow for larger, and more regionally or culturally diverse samples [64], and thus can support generalizability [28].

Lab Experiments

A large portion (n=16) of the user studies included in the analyzed paper set was conducted as *lab experiments* (defined according to [51]), i.e., in controlled laboratory environments involving one or more experimental conditions. All 16 lab studies asked the participant to either interact with a prototype or device, or to act out some kind of interaction, e.g., a gesture or voice command: *"Participants watched a video of an actor performing panning and zooming gestures in front of a wall and then performed themselves the same gestures 3 times"* [110]. Naturally, the increased level of control comes at the cost of a decreased ecological validity [52]. In a controlled, less vivid laboratory setting, devices and interaction styles might appear more salient than when tested in the field.

Field Experiments

In order to increase ecological validity, another large portion of studies (n=13) was conducted in natural settings, under controlled but realistic conditions with the researcher(s) present. Following the classification of research methods by [51] these studies would be classified as *field experiments*. A common practice for *field experiments* on social acceptability seems to be to choose highly frequented public locations as study setting, such as shopping malls [1, 7], urban parks [7, 68], cafés or restaurants [41, 65, 119], bus stops or public transport [76] and pavements at busy streets [68, 102, 132], but also locations on campus, such as university atrium [4], or university cafeteria [41, 87]. Lucero et al. [68] designed a walking route that included a busy main road, an urban park, crossing a bridge over a river, walking past a pub terrace, and near a children's playground. They argue that this allowed the participants, with the researcher following a couple of meters behind, to experience a range of casual audiences.

The choice of easily accessible public locations (e.g., cafés) has a number of advantages, including convenience, naturalness, and a large casual audience. However, experimental control is limited. In contrast to lab studies, busyness of places might not be constant, having potential effects on replicability and comparability. This is notable, as only very few papers contain information about presence and number of casual bystanders and passers-by (e.g., Lucero et al. [68]).

Field Surveys

Only three of the analyzed papers presented *field surveys*, which we define following Kjeldskov and Paay [51] as natural setting research where data collection methods such as diaries, log files, interviews etc. are used, instead of the researcher being present in the field. For example, Häkkilä et al [36] employed the Experience Sampling Method (c.f., Larson and Csikszentmihalyi [63]) to evaluate a smart glasses prototype in terms of privacy and social acceptability with regard to different contexts and interaction modalities. During a 5-day diary study, participants were prompted per text message, and asked to describe their current context (e.g., *"Approximately how many people were around you? What was their reaction?"*) along with imagined uses of the smart glasses device. On the first two days of the study, participants carried a smart glasses prototype with them that they put on as soon as possible when prompted. Williamson et al. [130] measured participant's interaction rates and subjective experience with regard to sensory determined context and activity (walking, using public transport) while interacting with a multimodal

RSS reader during their daily commute. Another work by the same authors [129], participants were encouraged to play a gesture-based mobile game in daily live while collecting usage logs, and user-reported data on location and user experience. While these methods are inevitably costly and time-consuming, they also provide a high ecological validity, and are able to uncover unanticipated motives, biases, and social acceptability issues [52].

Creating User Involvement: Study Procedures

Social acceptability is to a large extent experiential, and an aspect of social life that participants will typically be familiar with. Creating different types of user involvement as part of the study procedure can account for this.

Experimental Control and Stimuli

We found the analyzed studies to employ different stimuli and forms of experimental control. 59% of user studies included hands-on experiences (n=27) either with a prototype or off-the shelf device, or by trying out an interaction method. In the latter case, user interfaces were imagined, i.e., participants were instructed to act out the interaction (e.g., gesture or voice command) without a device or interface present. A small number of studies also provided the opportunity to observe other participants (n=5) while performing. Only one paper (Monk et al. [76]) involved only the researcher interacting with an interface. We further found that videos (n=14) have been re-occuringly used as stimuli in both, online surveys and lab experiments (here partially for instructory purpose). However, the extend to which the videos are shot in a way that depicts realistic interaction scenarios varied: while some studies purposefully aimed for *neutral* videos, e.g., an actor in front of a white wall [100, 110], others were shot to depict scenarios as realistically as possible, e.g., at a bus stop [92] or at varying locations, including a café, library, or street [105].

Co-creation and Discussion

Only a small number of papers actively involved their participants in the design process. Five papers presented guessability-style elicitation studies (n=5), and three papers reported having conducted focus groups (n=3). Except for where general HCI research practices can be applied (c.f., Wobbrock et al. [133] for elicitation studies) there is no established procedure on how to co-create ideas for socially acceptable interactions or interfaces. Lee et al. [65] suggest: *"To focus the study on social acceptability, we further adapted typical elicitation methods. To improve the ecological validity of the proposed actions, the study was conducted in a busy public place – a coffee shop"*. This illustrates that there is no existing guidance or practice on how to integrate the users' (or bystanders') views on social acceptability more directly in the design process (yet).

Quantifying Social Acceptability: Scales & Measures

As social acceptability is largely determined by the user's personal experience and how they subjectively perceive feedback from a present or imagined audience, it is not surprising that the majority of studies is based on subjective-quantitative (n=31), or subjective-qualitative (n=26) measures, where the latter is typically obtained from qualitative interviews, or open-ended survey questions. Only five of the analyzed papers (all of which focused on gestures) explored objective measures, such as interaction rates [129, 130], or interaction parameters such as duration, amplitude, or energy [102, 119, 127]. We also found a small number of study designs, where nominal data on social acceptability was collected, e.g., when participants had the choice to reject certain interaction areas or styles for social or personal reasons [48].

While a majority of studies used self-defined questionnaires (n=30), or made use of Rico et al.'s [102] audience-location axes (n=15), we found only two papers that employed cross-validated scales, namely the WEAR Scale [49] and the I-PANAS-SF [122], a (international) 10-item scale assessing positive and negative affects [115]. A questionnaire developed by Profita et al. [92] was taken up by one other work [109]. In the following, we go further into detail on how subjectively perceived social acceptability is quantified using questionnaires. In particular, we discuss the use of single- or multi-item scales, periphrases for *socially acceptable*, and the use of *audience and location* as a proxy for social acceptability.

Single-/Multi-Item Scales and Periphrases

Direct inquiry, using a single-item scale is the simplest way to approximate how socially acceptable a device or interaction method is perceived: e.g, Kim et al. [50] ask *"Social acceptance: is it acceptable to wear it in daily life?"*. In [53] the authors employ a combination of two items, namely comfort (*"How comfortable would you feel performing this gesture in an everyday public setting, such as a busy sidewalk?"*) and social acceptability (*"How acceptable would it be to perform the presented gesture in public?"*) to assess both user's and more general/bystanders' perspectives (5-pt. Kunin scale). Similarly, Pearson et al. [88] employ a 5-pt. Likert scale from 1 (*"completely unacceptable"*) to 5 (*"completely acceptable"*) to determine how participants rated the social acceptability of peeking at one's own/another persons warch during face-to-face conversations. These two examples are representative for quantifying social acceptability on 5-pt. or 7-pt. Likert [67] or Kunin scales [61]. But we also found studies to use other types of response options, e.g., single- or multiple-choice answers. For example, Ronkainen et al [105] combined aspects of desirability and willingness to use (*"Would you use this feature in your phone?"*) in a single-choice question providing different reasons for a yes/no decision. Similarly, Ahlström et al. [1] employ multiple-choice options featuring a range of reasons and impressions (e.g., *"I thought it looked fancy"*). While questions asked this way yield only nominal data, and thus have limited statistical power, they can help to better understand how users or observers feel about a given situation. Nevertheless, the fixed number of response options, and the way how they are phrased, might also introduce bias, and skew the given answers towards the given responses [35].

As also illustrated by these examples, *socially acceptable* human-machine interactions are often described or paraphrased using a range of adjectives that relate to impression management, occasionally combined with aspects of perceived usefulness or perceived utility. This approach can be beneficial, as it might be unclear, what *socially acceptable* means to a user, and whether study participants understand *social*

	cool	fancy	interesting	fashionable	stylish	useful	nerdy	natural	normal	noticeable	weird	embarrassing	annoying	disturbing	stupid	strange	inappropriate	awkward	impolite	silly	intrusive	rude	creepy	disfiguring
[1]		*	*								*		*	*	*	*	*							
[36]					*																			
[49]	*			*	*	*		*	*		(*)	*	*				*	*				*	*	*
[76]										*			*								*			
[77]												*												
[92]	*					*	*		*					*			(*)	*				*		
[93]	*							*	*		*	*	*					*	*	*				
[105]						*														*				
[109]						*			*								(*)	*				*		

Table 1. Periphrases of *social acceptability* used in questionnaires. Brackets (*) indicate the use of a negation, e.g., 'not weird'. Negatives (right) are used more frequently than positive (left) or neutral (middle) adjectives which reflects the definition of social acceptability as absence of negative feedback.

acceptance the same way as the researchers. We provide an overview of adjectives employed to paraphrase *socially acceptable* in Table 1. Many of those adjectives are loosely tied to impression management, or how a user's interactions might be perceived by others. However, conceptualization attempts (as discussed in [57]) are only sparsely present in the analyzed set of papers. There is (so far) limited knowledge on how individual adjectives or items might cohere, or relate to superordinate constructs. We find a strong focus on adjectives with a negative connotation (e.g., weird, annoying), which reflects social acceptance being typically defined through negation, or an absence of negative judgment. We also found a similar choice of adjectives to be used to replace *socially acceptable – socially unacceptable* in rating scales (e.g., Likert scales). Examples include e.g., *embarrassed – comfortable, foolish – sensible* [122]. Similarly, semantic differentials, i.e., sets of multiple, bipolar pairs of adjectives (c.f., [15, 75]) have been used to measure the emotional response of participants, more specifically their attitude towards an interaction with a device in a certain situation or scenario [54, 56].

Summing up, in terms of single- or multi-item scales, there is no agreed upon way to ask for social acceptability. Although there are questionnaires that have been re-used [92, 109], as well as sets of cross-validated items that have been proposed [49, 122], evaluations largely depend on self-defined, custom questionnaires. These practice induces a couple of potential issues, including low comparability and potential bias or skew. In addition, questions are often phrased to exactly match the to-be-evaluated prototype or interaction style. In consequence, they are often not well transferable and do not well generalize. The practice to use adjectives to paraphrase social acceptability can be beneficial in terms of illustration, but might induce the danger of a reduced reliability due to untested selectivity/separation effects between adjectives if used as single choice questions. It is furthermore unclear to what extend the selection of used adjectives overlaps with other constructs that might or might not correlate with social acceptability, e.g., hedonic quality [38, 40]. These aspects illustrate the difficulty of creating a set of questions/items that provides a reliable and transferable measure of social acceptability. The use of audience-and-location axes to proxy social acceptability, which we will discuss in the next section, seems to be a popular way to circumvent this difficulty.

Audience-and-Location Axes

Although the use of *location* to describe *social occasions* as a proxy measure for social acceptability of a human-machine interaction had already been employed earlier [19], Rico's and Brewster's "audience-and-location" axes, as first presented 2009/10 in [100, 101], were the most widely used quantitative measure for social acceptability in the pool of analyzed papers (n=15). Their selection of audiences (alone, partner, friends, family, strangers, and colleagues), and locations (at home, while driving, as a passenger on a bus or train, on the pavement or sidewalk, at a pub or restaurant, and at the workplace) has been taken up, employed, modified and extended by numerous researchers. Depending on the evaluated interaction methods and evaluation context, some of them excluded "while driving" [10, 44] or added locations, e.g., "museum" and "shop" [1]. Other authors grouped audience and location into plausible "social situations", e.g., Home, family; Work, colleagues [29, 110]. The questionnaire has been adapted for different types of interactions including wearable devices and sensing [10, 33], on-body or textile input [85, 93], and employed in lab (n=6), online (n=5) and field (n=5).

At first, the audience-and-location axes were phrased as multiple choice questions: *In which locations would you use this gesture?*, and *Who would you perform this gesture in front of?*, respectively. This yielded binary ratings for each location/audience; results were then aggregated as scores (or "acceptance rates"), typically calculated as a percentage of positive responses [29, 44, 65, 101]. To increase explanatory power, the questionnaire was later adapted by other researchers using various Likert scales, e.g., 5-pt. [3, 4], or 10-pt. [10].

The audience-and-location axes have the advantage of a clear discriminatory power, and are easy to understand (for both researchers and participants) and easy to use. They provide a very useful metric for an interaction's overall social acceptability, based on the fundamental question "would the user be willing to interact with the system?". On the other hand, they only provide a somewhat "absolute" measure of social acceptability. Albeit the choice of independent variables (e.g., by evaluating different variants of an interaction) can provide some indication, the measure itself does not provide insights about what factors contribute to an interaction being more or less socially accepted. In particular, audience-and-location do not provide insights about the experience, or emotional response, to the evaluated interactions.

In principle, "acceptability scores" could be compared across multiple studies. However, this is not easily possible with the present set of studies: different works compute scores differently, e.g., as percentage of positive responses per location/audience [1, 101], or as the percentage of selected audiences/locations per experiment condition [65]. Moreover, only few papers reported all obtained scores [29, 44, 85]. Instead, most of the analyzed papers only reported selected scores (e.g., for one specific gesture), or used bar-chart representations to illustrate relative scores (e.g., of different experiment conditions) without providing concrete numbers. In consequence, comparability of scores is (so far) limited. Most notably, there is – to the best of our knowledge – no work on the measuring instrument itself. Albeit results seem to be consistent across studies (noted by Freemann et al. [29]), the audience-and-location axes are not (yet) validated in a strict sense. Also, it is so-far unclear what constitutes an "acceptable" social acceptability score: while a low score indicates that an interaction technique or interface will most likely have social acceptability issues in the field, it is unclear if a high score, although promising, can predict or guarantee socially acceptable interaction in public; An uncertainty which is not unique to the audience-and-location axes, but had, for instance, been noted on the system usability scale, SUS [11].

DESIGN STRATEGIES

Improving social acceptability can motivate designing an interface or interaction technique in a specific way. Similarly, certain design features can turn out to hinder or promote social acceptability. While not all of the analyzed N=69 papers elaborate on how social acceptability can be influenced (either positively or negatively) through the design of interface or interactions, we found *design strategies* to increase social acceptability to be a re-occurring theme (n=52). Twenty-nine papers discuss or present design strategies as a result of their empirical research. Seven of them provide concrete design recommendations or best practices [1, 3, 29, 56, 101, 111, 130], all of which empirically backed. In addition, we found 23 papers to employ design strategies to increase social acceptability in research prototypes (or modified consumer devices, c.f., Profita et al. [95]). Surprisingly, only 9 of them evaluate the effect of those strategies. In the following, we go into detail on which design strategies were suggested or employed, the contexts in which they were tested with users, and then combine and discuss the results comprised by all 52 papers.

Subtlety, Unobtrusiveness & Avoiding Negative Attention

The most popular strategy to create socially acceptable human-machine interactions is *subtlety* (n=32). In fact, as Pohl et al. [90] note *"[t]here is a common underlying assumption that systems that are hard to detect by others increase social acceptability"*. While *subtle* can (in principle) be used to describe secretive or deceptive interactions [6, 90], the analyzed set of papers displayed a general tendency towards unobtrusive, but visible and revealed interactions as opposed to hidden interactions (c.f., Reeves et al. [98]). Choices of subtle (or unobtrusive) interactions were prevalently motivated by the designer's choice to *"de-emphasize"* [94], or the users' desire to *"blend in"* [55], *"not draw attention"* [85], or *"not advertise"* device usage [94], as well as be non-disruptive. For example, Paay et al. [87] found participants to be conscious about not impairing others' physical space while (gesturally) interacting with large public displays, and to prefer techniques involving smaller movements. Similarly, in the context of around-device gestures, Ahlström et al. [1] showed that small gestures, and gestures with a short duration were significantly more socially acceptable than more expansive, and more time-consuming gestures, as these avoid negative attention.

On the other hand, Rico et al. [101] also note that *"the ability to disguise [some] gestures as everyday activities appears to make them more acceptable"*. They exemplify foot tapping as a gesture that despite requiring relatively high energy to complete (i.e., having a large movement amplitude), is perceived as socially acceptable, due to its resemblance to tapping a rhythm while listening to music. Similarly, trouser pockets were appropriated to make interactions with interactive textiles less conspicuous and more natural [48]. Further elaborating on this approach, Lee et al. [65] identify miniaturizing, obfuscating, screening, camouflaging and re-purposing as design strategies for subtle, socially acceptable hand-to-face (gestural) input, and ask participants to come up with matching gestures. This procedure also illustrates, that in the context of social acceptability, subtlety is often understood as a prerequisite rather than a design strategy: *"Participants were [..] instructed to generate unobtrusive or subtle actions, suitable for use in the public setting of the study"*. We found 32 papers discussing or employing subtlety as a design strategy, but only 18 (56%) providing some (quantitative or qualitative) verification of the strategy's effect. In consequence, there is the risk that subtlety might be seen as universal remedy to social acceptability issues – while effective in some, also in cases where it is not.

Avoiding Suggestiveness & Misinterpretation

As impression management is largely concerned with how users expect to and want to be perceived by others, it becomes highly relevant how interaction techniques might be interpreted when observed. In consequence, the potential of a specific interaction to be misinterpreted can influence social acceptability. There is a multitude of scenarios, where an interaction with a device might be mistaken as (non-verbal) communication targeted at bystanders, e.g., insults (c.f., Serrano et al. [110]) or could (potentially) be misinterpreted in a way that impairs the user's public image, e.g., scratching (c.f., Weigel et al. [127]) as sign of poor body hygiene. Prior research in the area of gestural interaction confirmed, that commands that (inherently) emphasize that they are directed towards a device, are socially more acceptable than interactions that do not [29, 77, 101]. Rico et al. hypothesize: *"[U]sers are more willing to use a gesture if it provides visual cues that explain their behavior"* [101]. Making the interaction context, e.g., the type of application or the user's intention, clear and observable can further avoid misinterpretation and increase social acceptability [53]. In the context of on-body and textile input, suggestiveness of certain body-areas can cause an interaction to be perceived as obscene or sexual. In the analyzed set of papers we found groundwork providing body maps [26] as well as indications for e.g., gestures or body-areas that might be problematic [41, 48, 93], and reports of gender effects, e.g., different perceptions regarding the chest area [26, 93].

Accessory-like Shapes & Familiar Styles

Style of dress and impression management are tightly related. Similarly, wearable computing devices have traditionally aimed to emulate shape and styles of non-digital accessories. In consequence, the use of *accessory-like shapes* and *familiar styles* has been recognized and discussed as technique to increase social acceptability early on. Rekimoto et al. [99] note: *"In other words, we believe 'unobtrusiveness' of input devices is essential for them to be used in everyday situations. One possible way to design such devices is to embed input sensors to conventional wearable items, such as wristwatches or clothing"*. In our analysis, we found these design strategies to be present in 12 papers of which half provided empirical evidence for its effectiveness (50%, n=6).

The use of familiar styles resembling non-digital accessories has been argued e.g., for (smart) glasses [42, 72], finger rings [84] and smart watches [74] or wrist bands [83]. Dierk et al. [25] explore hair as interactive material for inputs and outputs. They argue that *"[t]he surreptitious nature of the interface allowed a user to take an action without offending a friend or acquaintance"* and report that participants *"preferred the more subtle possibilities for technology embedded in something as ubiquitous as hair"*. This shows parallels to the appropriation of familiar, and thus perceived less obtrusive gestures [48, 65, 101], as discussed in the previous section.

In the context of assistive devices, resemblance to non-digital accessories as well as non-assistive consumer devices has been reported to minimize stigmata [111]. Nanayakkara et al. motivate: *"The finger-worn device [..] follows this design paradigm: it looks and offers the same affordances and mode-of-use to both sighted and blind users in a self-sufficient way"* [79]. In this context the resemblance to consumer devices can also be understood as a kind of *unobtrusiveness* or unconspiciousness, as it causes the device, and in consequence its user, to stand out less [94].

Candidness, Transparency & Justification

The visibility of effects and manipulations, as formalized by Reeves et al. [98], has been frequently linked to an interaction's social acceptability. While, as discussed in the previous sections, some prior work promotes inconspicuous, i.e., subtle or unobtrusive interactions, other researchers suggest to provide some explanation along with the interaction. Ens et al. [27] promoted the social acceptance of their prototypes by making effects of the manipulations more observable, i.e., *candid*. While not as frequently employed as design strategy as *unobtrusiveness*, with only 4 papers employing *candid* designs [27, 47, 89, 95], we found candidness to be backed by multiple empirical studies (n=7).

Referring to Reeves et al.'s classification of interfaces along the axes of hidden or revealed manipulations and effects (illustrated in Figure 4), interactions could be *secretive*, *magical*, *expressive* or *suspenseful* [98]. Ens et al. hypothesize that suspenseful interactions (revealed or amplified manipulations, hidden effects) tend to be socially awkward [27]. This suggestion is backed by earlier findings: For example, Montero et al. found magical (hidden manipulations, revealed or amplified effects) to be more socially acceptable than suspenseful gestures [77]. A similar effect had been observed even earlier by Monk et al. who compared the annoyance caused by overhearing a mobile phone call to overhearing a face-to-face conversation: social acceptance decreases when only half of the dialogue is audible [76]. Interestingly, the hypothesis that candidness increases social acceptability holds from both users' and bystanders's perspectives. Häkkilä et al. [36] report that in their studies, participants indicated a desire for justification: they were concerned about *"assumptions other people might be drawing about the expected use of the device. Several participants mentioned nearby people would think them doing something unethical or forbidden"*.

Most notably, the question *"what is done?"* respectively *"what is the purpose of the interaction?"* has been shown to have a significant effect on social acceptability as seen from a bystander's perspective [56, 92]. In addition, social acceptance can depend on utility, i.e., how helpful for the user the device is expected to be [7, 92]. Profita et al. found that smart glasses used by a visually impaired person were perceived significantly more socially acceptable when the disability was disclosed [92]. In addition they found that social acceptability was affected positively when it was communicated *"how the device was used"*. More specifically, the interaction was rated with a higher social acceptability when the device was described as being used for an assistive purpose, and more negatively when being used for a personal purpose, or when no usage intention was specified. Similar effects have been described by Alharbi et al [5] and Ahmed et al. [2] in the context of wearable cameras. While these two studies do not focus on social acceptability and thus are not part of the analysis, they also illustrate that aspects of justification intensify (as suggested by Profita et al. [92]) where technologies are used that may affect bystanders more directly, e.g., those involving recording or sharing of information.

Finally, it has to be noted that a preference for *candid* or *transparent* design strategies does not necessarily imply that bystanders would be informed about all details of the interaction. It is rather about providing bystanders with a broad notion of what manipulations mean (as also suggested by Montero et al. [77]). Nevertheless, how this could be achieved by design is only sparsely covered in literature. Particularly the creation of a balance between privacy [27] or stigmata [95, 111] and justification or bystander awareness [60] seems to be a challenge for future research.

DISCUSSION

In this section, we reflect on our structured literature analysis, and discuss the impact of current practice and distribution of research and design approaches. We identify methodical gaps, and argue for a shift in direction to better address these gaps.

For more User Involvement, Ethnography & Co-creation

Social acceptability arises everyday, with digital and non-digital objects and with established and novel human-computer

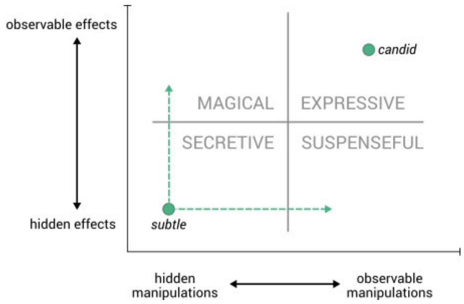

Figure 4. Interactions may hide or reveal manipulations and effects; Dimensions according to Reeves et al. [98]. Social interactions can be classified as magical, expressive, secretive and suspenseful. Interpretations of "subtle" vary [90], but candid is typically expressive [27].

interfaces alike. Thus, we might expect users to be experts in impression management and social acceptability. However, we found that only 8 of the analyzed papers (12%) actively involved participants in the design process (c.f., the section on Co-creation and Discussion, and Figure 3). Only one paper looked into existing practices (glancing at one others watch, Pearson et al. [88]), albeit in a laboratory environment. None employed ethnographic methods, e.g., observational approaches in naturalistic settings. Instead, in the majority of studies, participants were asked to rate a pre-defined set of options (e.g., commands) or indicate how socially acceptable they perceived interacting with a research prototype. In the latter case, we also see a tendency to focus on "successful" evaluations, i.e., utilizing user studies to show that a specific interaction technique or research prototype meets social expectations or scores higher than a hypothesized "social acceptability level". While those summative evaluations are important to assess an interface's internal and external effects under realistic conditions, they come late in the development process where design-related social acceptability issues might be costly to resolve. In contrast, elements of ethnography, participatory design and co-creation can inform and shape designs, as illustrated by examples of elicitation studies [65], and focus groups [102, 131]. Their more formative approach could contribute to design processes that consider social acceptability, alike user experience, from the beginning and not as an afterthought. There is a significant body of work that may serve as inspiration: participatory design methods have been comprehensively used to design sociable robots [8, 66]; Social Impact Statements have been proposed as a tool to engage public participation, and to address potential negative influences of computing on society and the self-image of individuals [112]. Research on Value Sensitive Design proposed methods for eliciting the users' values, and for addressing the involved risk of unintentionally stating one's own (the researcher's) values, as if they had been articulated by the participants [14]. In summary, there is an existing knowledge base that can be adapted and made use of to address social acceptability issues in early development stages.

> **Gap 1**: To date, social acceptability is only sparsely considered during early development stages. We need to increase both user and bystander involvement and consider their views on social acceptability earlier, during phases of requirement analysis, design and prototyping.

For Diversifying the Set of Methods

There is a bias towards study types with high levels of experimenter control, i.e., experimental settings where one or more researchers are present at all times (c.f., Figure 1). More precisely, social acceptability issues are commonly evaluated in lab (n=14), or field experiments (n=13). Similar to Kjeldskov [52], we found different understandings of what constitutes a "field setting", but most works opted for relatively easy to control, confined settings with moderate throughput of passers-by, and a range of casual audiences, such as cafés, or university cafeterias. These locations, while offering a contextual (social) backdrop, provide only limited social context, e.g., in terms of user-bystander relationships, and typically cover only a section of potential usage scenarios.

In addition, survey-style research administered online or in lab/classroom settings (n=15), is highly popular. There, participants typically rate pre-defined scenarios based on visual stimuli, e.g., videos. Evaluation methods with low experimenter control, e.g., where participants exploratively try out interfaces and record experiences during everyday activities are much less common (field surveys, n=3). From our perspective, this constitutes a significant weak spot in today's HCI research on social acceptability. This also reflects in current study approaches being frequently criticized for containing an "imaginary" component, i.e., participants are asked to imagine how they would feel in a certain social situation, instead of being in that situation. Complementing controlled experiments with studies in more naturalistic, unconstrained settings would help to obtain a more comprehensive image, including unanticipated social acceptability issues.

HCI literature and practice provides a rich fund of methods, including field trials where participants act as investigators [17], cultural probes [31], various forms of technology probes [45] and experience sampling [36, 63]; with collected data ranging from system logs [130], user interviews, and observations or video vignettes [104]. We should make good use of it!

> **Gap 2**: To date, social acceptability is mostly evaluated in highly to moderately controlled settings. We need to show courage to tackle more naturalistic study settings and embrace mixed method approaches more, where controlled and unconstrained study settings can be complimentary.

For Closing the Loop

There is a mismatch between papers that present design strategies as results of empirical studies (n=29) and papers that employ design strategies to enhance the social acceptability of artifacts they create (n=23). In addition, only 9 of the latter works confirm the effectiveness of the employed strategies empirically. Ideally, results from the first group of papers (empirical studies on social acceptability) would inform the creation of artifacts (second group of papers). Then, created artifacts would be empirically evaluated to supplement or confirm the assumptions made based on the initial set of empirical results (in principle, what HCI and human-centered design is best at [46]). Yet, in practice insights on what might improve social acceptability are often overly simplified when fed back into the creation of research prototypes: for example, subtlety (or unobtrusiveness) is often equated with going unnoticed, i.e., the use of secretive interactions or small devices. However, empirical work shows that, in fact, interactions that do provide an explanation (c.f., Williamson et al. [132]) but (being subtle) do not call (negative) attention to it are likely to be better acceptable than fully hidden and unnoticeable (e.g., suspenseful) interactions [76, 77]. In this context, subtlety is rather understood as non-intrusive, or non-disruptive. In addition, as noted by Pohl et al. [90] there are the still to be investigated (social) costs of a secretive interaction being uncovered. Thus, creating interactions to be unnoticeable for bystanders would not be an cure-all remedy in terms of social acceptability, but would rather disregard aspects such as authenticity and honesty (justification), helpfulness (utility) and the avoidance of misinterpretations that have been shown to be relevant to social acceptability. Admittedly, there is limited knowledge how this balance between different design strategies (e.g., unobtrusiveness and candidness) can be achieved in practice, and a lack of best practices, and concrete ideas on how those design strategies could and should be implemented. These will have to be provided by future work.

> **Gap 3**: To date, there is a gap between recommendations for socially acceptable interface design based on empirical studies, and design strategies employed in the creation of prototypes. We need to bridge this gap by ideating concrete designs that fulfill these requirements, and implement, test and verify them in research prototypes.

For Measures beyond Audience & Location

There is a lack of established, standardized questionnaires that measure different facets of social acceptability. We found 15 studies that used the audience-and-location axes originally suggested by Rico and Brewster [100, 101]. While this may indicate a consensus or local standard, audience-and-location only measures social acceptability by proxy. Namely, whether user's would be willing to perform an interaction in front of a certain audience or at a certain location. This approach allows to efficiently compare different options, but lacks the ability to directly pin-point issues: design aspects that positively or negatively affect social acceptability have to be backtracked from the provided options. More precisely, the use of audience-and-location does provide a utile estimate of "total" social acceptability, but does not split up into sub-concepts. In consequence, the measure's ability to provide insights about what could be improved about a design is limited. The development and use of (validated) subscales (c.f., NASA-TLX [37]) to capture different aspects of the experience could aid to parse design-relevant aspects (e.g., product qualities) apart, and provide clearer staring points for improvements.

So far, work on scale development and validated measures, as e.g., by Kelly et al. [49], has not been re-used, evaluated, or extended by other researchers. Instead, evaluations largely depend on self-defined, custom questionnaires, which impairs comparability, and – potentially – validity. Our analysis showed that in questionnaires *social acceptability* is often described or paraphrased using a wide range of different adjectives (see Table 1). There, we find parallels and overlaps with existing measures and models: The set of adjectives includes aspects of perceived usefulness or perceived utility (as e.g., in TAM [24]), as well as impression management and social norms (e.g., *"inappropriate"*, *"impolite"*, or *"intrusive"*). We furthermore find overlaps with the previously discussed design strategies (e.g., *"noticeable"*). Moreover, Table 1 illustrates how social acceptability measures fall into line with research on experienced qualities of human-machine interfaces: *"stylish"*, and *"fashionable"* relate to prior work on aesthetics and attractiveness [96], and notions such as *"coolness"* had been researched comprehensively in the context of user experience [18, 97, 113]. These adjectives also show parallels to the anchors used by Hassenzahl [38] to determine hedonic quality-identification, e.g., isolating – integrating (HQI_1), gaudy – classy (HQI_3), unpresentable – presentable (HQI_7). This illustrates that our understanding of what makes up social acceptability is still evolving. In consequence, developing a measure that reflects the construct social acceptability most adequately (i.e., has high validity) requires more than well-phrased items and suitable scales. It needs further community-wide discussion and conceptualization of social acceptability, and a better understanding of individual factors that increase and/or decrease social acceptability. Also, social acceptability should not be viewed in isolation from other qualities and affects connected to user experience. Instead, future work should aim to determine where existing constructs overlap, complement or contradict with social acceptability measures, or also strive to identify social factors that act as hygienes or motivators (c.f., Tuch and Hornbæk [118]). We believe that our analysis of adjectives/items that are already in use can provide a valuable starting point for these efforts.

> **Gap 4**: To date, social acceptability is mostly measured in a simplified, proxied fashion using audience and location. We need to develop measures (e.g., questionnaires) that differentiate design-relevant aspects of social acceptability, and that allow to evaluate interfaces in a more diagnostic, and problem-oriented way.

CONCLUSION

In this work, we reviewed papers on social acceptability in HCI. During the nearly 20 years covered by our analysis, a significant amount of contributions to a better understanding of social acceptability (and impression management) in HCI were made. However, we also identified gaps in the distribution of research approaches. In particular, ethnography, participatory design and field research in naturalistic settings without the researcher's presence were only sparsely employed. Moreover, we showed that the consideration of social acceptability is not yet interwoven with the whole design process: results from empirical work on social acceptability do not propagate to the creation of socially acceptable designs or prototypes. Last but not least, we discussed the current lack of established, standardized questionnaires quantifying social acceptability in a non-proxied fashion, and highlight the need to develop differentiated and truly operational measures. We hope to inspire more discussions about what constitutes social acceptability in HCI [57, 58], what constructs it might comprise (e.g., "coolness" [18, 97]), and how design activities can be proactively oriented toward influencing social acceptability.

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Papers included in the structured literature analysis are marked with labels in **boldface**.

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