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A SYSTEMATIC LITERATURE REVIEW OF PERSUASIVE DESIGN FEATURES UTILIZED BY MOBILE-BASED OBESITY INTERVENTIONS

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ABSTRACT

Mobile interventions utilizing persuasive technology represent considerable promise in effecting long-term success against obesity. This study conducts a systematic review of the literature on the persuasive technology features utilized by different mobile interventions geared toward obesity, categorized using an amended Persuasive Systems Design model. Published studies were gathered from the following databases for this study: EBSCOHost Computer & Applied Sciences ACM Digital Library, IEEE Xplore, Scopus, and SpringerLink. Nine mobile interventions collected. The results show that persuasive design features related to Primary Task Support and Dialogue Support commonly supported, while persuasive design features related to Social Support that were less supported. This may indicate that current mobile interventions focus more on individuals, rather than on communities. This study will be useful for developers of mobile interventions geared toward obesity, as it reveals the persuasive technologies used by current interventions to motivate their users.
Keywords: *Obesity, Mobile Interventions, Users Behavior, Persuasive Technology*

1. INTRODUCTION

Obesity is currently understood by medical experts to be caused by personal habits namely, a surplus of caloric intake and a lack of physical activity which are, in turn, influenced by environmental and emotional factors [11], [14], [18]. The interaction between personal, environmental, and emotional factors generally accepted to be the cause of obesity. It is therefore necessary to disrupt the interaction of these three factors in order to prevent or treat obesity in the long-term.

Current interventions for obesity make use of mobile technologies and persuasive technology to treat obesity holistically [2]. Mobile interventions for obesity have three main advantages over traditional, face-to-face interventions for obesity. First, mobile interventions are cheaper and easier to maintain; second, because they are cheaper and easier to maintain, mobile interventions are convenient they are accessible to obesity sufferers when they need it most; and lastly, they are more capable of being responsive to the user's needs [3],[8],[17].

In recent years, mobile interventions for obesity have overtaken traditional interventions. Results have been promising, especially for interventions that make use of persuasive technologies to improve user compliance. According to studies conducted by [1] and [12], mobile interventions for obesity have resulted in their users' body mass index (BMI) reductions, increased physical activity, and improved nutritional habits. However, Badawi et al. [2] observed a key limitation of such studies, in that the first waves of mobile obesity interventions do not make use of personalized recommendations, which been found to be most effective in helping sufferers overcome obesity. In the long-term, this may be a limitation inherent to the technology during that time. Furthermore, because mobile interventions are new, there is still a lack of clarity on whether such interventions work in the long-term, as not enough time has passed to conduct many longitudinal studies on the interventions' effectiveness.

This study conducts a systematic review on the persuasive technology features utilized by current mobile interventions for obesity, based on the Persuasive Systems Design (PSD) model

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developed by Oinas-Kukkonen and Harjumaa [15], building on the research on persuasive design by Fogg [6]. The PSD model was created as a means of evaluating systems tasked with changing attitudes and behaviors of intervention users [9], which makes it well-suited for the purpose of this study. The categories of the PSD model are primary task support, dialogue support, system credibility support, and social support. Each category has seven sub-categories. The PSD model utilized in this study excludes system credibility support due to the difficulty of procuring and testing the exact version of the technologies used in the studies. A detailed discussion of each category, including their sub-categories, in the PSD model is provided in the Appendix. By reviewing the current state of mobile obesity interventions and evaluating their use of persuasive technologies using the PSD model, this review seeks to identify the commonly selected features and possible gaps of mobile obesity interventions today. By knowing these gaps from previous studies this will be a contribution for future studies and help researchers.

The rest of the study organized as follows. Section 2 presents the methods utilized in this study, and section 3 discusses the findings obtained by the study. The final section includes the conclusion of the study, as well as directions for future research.

2. METHODS

2.1 Literature Search

A search of various databases was conducted in order to reveal articles relevant to the inquiry of the study. The following online databases were utilized to generate articles for this review: EBSCOHost Computer & Applied Sciences ACM Digital Library, IEEE Xplore, Scopus, and SpringerLink. The search was conducted on February 2020, and limited the publication date from 2015 to 2020. Because each database is found to respond differently to keyword search terms, a number of search terms utilized, and the search terms that elicited the highest number of results was selected for final inclusion of the review.

For EBSCOHost Computer & Applied Sciences, we used "obesity intervention AND persuasive technology" as well as "obesity intervention AND mobile AND adult". For IEEE Xplore, we used "obesity intervention AND mobile" and "obesity AND intervention, mhealth OR app". For Scopus, we used the following search strings: "**(**"*obesity intervention"* AND *mobile*)) AND (app)", "(*"obesity intervention"*)) AND (*smartphone* OR *mhealth*)", and "(obesity AND *mhealth*)) AND (persuasive)". For ACM Digital Library, we used "obesity intervention" and "persuasive technology AND obesity".

2.2 Inclusion and Exclusion Criteria

To be included in the review, articles must meet a set of criteria. First, the article must either: (1) Published in a peer-reviewed academic journal, (2) Scheduled published this year in a peer-reviewed academic journal, or (3) a peer-reviewed article from an indexed publication or an international computer science conference, all within the past five years. Second, the article must contain a finished mobile intervention for obesity geared toward adults, which makes use of persuasive technologies, delivered via a smartphone, tablet, or similar device. Third, the article's mobile intervention for obesity must have undergone empirical testing in a real world setting. Articles are excluded if they did not contain a mobile obesity intervention for adults, contained a non-finished mobile obesity intervention, or did not test their mobile obesity intervention in a real world setting. Previous reviews are also excluded, as they do not contain any empirical tests of mobile obesity interventions.

2.3. Data Extraction

Through the inclusion and exclusion criteria discussed above, a final list of articles were identified for analysis.

First, the list of articles gathered from the selected keywords were browsed through to eliminate articles whose titles clearly indicated a focus other than mobile obesity interventions. These included mobile interventions for other diseases, such as substance abuse, prescription medicine compliance, and so on. Redundant results were also eliminated, such as when an article emerged in two different databases.

Furthermore, childhood obesity interventions were also excluded, as the persuasive technologies used to influence children will likely differ from those used for adults. Second, the abstracts of the remaining articles were read, eliminating a number of articles because their abstracts revealed that they did not focus on mobile obesity interventions for adults. Third, the remaining articles' full texts were read to determine if each contained the inclusion criteria for the review.

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The resulting articles were evaluated using an amended version of the PSD model as a framework. Data extraction and coding accomplished by combing through the articles for quotes that indicate the persuasive technologies utilized for their mobile obesity interventions, then coding them into a spreadsheet on Microsoft Excel. The individual features were then classified within the PSD model's four distinct categories: primary task support, social support, system credibility support, and dialogue support. Each category contains seven sub-categories. No coding discrepancies were found between authors, and final coding proceeded with consensus among the authors on how each article coded.

Figure 1 illustrates the data extraction process undertaken in the study.

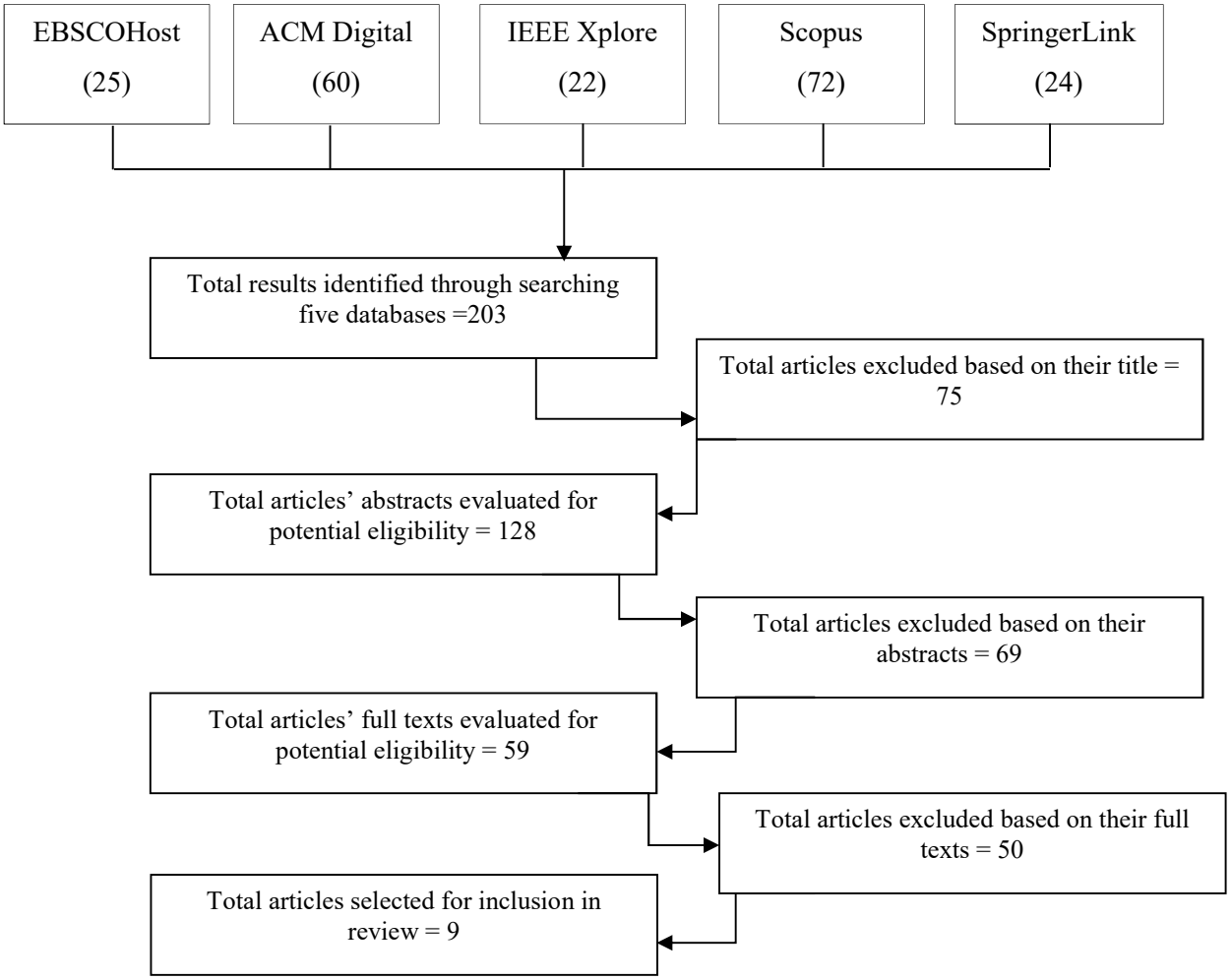

Figure 1. Data Extraction Process

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2.3. Results

The final list of articles from the search of five online databases resulted in nine studies for inclusion. Of the original set of 203 studies derived from the keyword search, 75 were excluded upon considering their titles, which revealed a focus other than mobile obesity interventions for adults. Total 69 more studies excluded upon examining their abstracts, due to the studies focusing on childhood obesity, on obesity-related diseases, and other reasons. After reading through the full texts of 59 studies, 50 were excluded, primarily due to the lack of empirical testing on their mobile intervention for obesity. The remaining nine articles were comprised of three randomized controlled trials, two pilot randomized controlled trials, one protocol/early results randomized controlled trial, one was a longitudinal observational study, one was a pilot comparative efficacy trial, and one randomized controlled efficacy study, as presented in table 1 below.

Table 1.Intervention name, study type, and sample size of included articles

Study Number	Authors	Intervention Name	Study Type	Sample Size
1	Bender et al. (2016)	PilAm Go4Health	Protocol/early results randomized controlled trial	*N*=45
2	Bender et al. (2017)	PilAm Go4Health	Pilot randomized controlled trial	*N*=45
3	Hutchesson et al. (2017)	The Biggest Loser Club	RCT	*N*=301
4	Lin et al. (2018)	Cell Phone Intervention For You	RCT	*N*=122
5	Mummah et al. (2016)	Vegethon	Pilot RCT	*N*=17
6	Partridge et al. (2019)	TXT2BFiT	RCT	*N*=214
7	Spring et al. (2017)	ENGAGED	Randomized Controlled Efficacy Study	*N*=96
8	Stein et al. (2017)	Lark Weight Loss Health Coach AI	Longitudinal Observational Study	*N*=70
9	Wang et al. (2018)	LoseIt!	Pilot comparative effectiveness trial	*N*=26

The persuasive design features were coded based on whether they were included in the mobile intervention, not whether the technology contained in the intervention supported them. For instance, some of the smartphone apps linked to social networking sites for group discussions, instead of within the app. Such instances were still coded as social facilitation. Other persuasive design features that were supported outside the app coded similarly. The frequencies of each study for the different principles enumerated by the PSD model are presented in table 2 end of the document. Study numbers are listed alphabetically. This visual table presenting the data provide clear and means of features utilization in the range of articles numbers.

3. DISCUSSION

This section discusses the results obtained by the study.

3.1. Primary Task Support

Primary task support was defined by Oinas-Kukkonen and Harjumaa [15] as the design principles that help the user carry out the main task of the intervention. In this study, this means in assisting the user overcome obesity as defined by

the obesity interventions reviewed. Based on the review, the support offered by mobile interventions for obesity today is robust.

All nine interventions reviewed contained self-monitoring features, which were accomplished either by manually inputting relevant data, such as meals, weight change, and duration of physical activity, or by automatic recording of data such as step counts. Rehearsal was also present in all nine interventions. Tunneling and reduction were also highly represented, with seven instances each.

On the other end of the spectrum, rehearsal and simulation had just four and two instances, respectively. The setting of long-term goals is a key component of many interventions, which allows users to rehearse the correct personal habits in pursuit of their health goals; Bender et al.[4],[5], Mummah et al [13], and Stein et al. [20] helped their users rehearse the planning of healthful, nutritious meals in the long-term. Other interventions merely offered suggestions for future meals. Simulation was a difficult feature to integrate into interventions. The studies conducted by Bender et al. [4],[5] were able to include them by showing before and after pictures of users on their community groups to serve as models and encourage other participants.

Overall, most of the persuasive features associated with primary task support are present in current mobile interventions for obesity. This is no surprise, as it is often simplest to focus on personal factors to obesity, such as rate of physical activity and rate of fruit and vegetable consumption. The convenience associated with smartphones and similar technologies make it easier to tailor and personalize recommendations, as well as keep an accurate record of user progress.

3.2. Dialogue Support

Dialogue support is important in persuasive design because it helps users feel less alone in pursuit of their goals, which keeps them motivated. Computer-human dialogues can help users feel supported, especially if they do not have friends or family members facing the same struggle.

Persuasive features associated with dialogue support similarly supported in current day mobile interventions for obesity. The most common persuasive features are liking, suggestions, and reminders, with eight instances each. It is important for interventions to be visually appealing in order to encourage compliance and engagement [15]. Reminders and suggestions are also common as their delivery during key times such as meal times add to their persuasiveness toward the target behavior. Only the article by Wang et al. [21] failed to use reminders or suggestions with their LoseIt! App; instead, the app relied only on self-monitoring measures, augmented by their intervention's social tone and audience-friendly design.

An interesting result is the lack of similarity in the interventions, with just Stein et al. [20] making use of it with their Lark Weight Loss Health Coach AI to adjust automatically to users' specific states such as food and drink consumption, sleep duration, and weight to mimic empathy. However, Bender et al. [4],[5] utilized similarity outside their technology by adopting the vernacular of their Filipino-American sample in different stages of the intervention.

3.3. Social Support

Some persuasive features associated with social support supported as well by mobile obesity interventions today, but to a lesser degree than features on primary task and dialogue support. Recognition, competition, normative influence, social comparison, and social learning each garnered five instances. Social facilitation had just three instances, while cooperation had just one. The lack of social support features in current mobile obesity interventions indicates a focus on individuals rather than communities in tackling obesity.

One interesting thing to note is the lack of certainty on how to utilize cooperation or competition among interventions. Cooperation was featured solely by Lin et al. [10], which utilized a buddy system that linked two users, allowing them to share messages, and health-relevant data while retaining anonymity. Mummah et al. [13] argued that, while competition could spur some users, it could also discourage others, especially to those far behind top ranking users.

3.4. Gaps in the Literature

Primary task support features strongly represented across the board in current mobile interventions geared toward obesity, aside from tailoring and rehearsal four instances each and simulation. As mentioned before, the personal factors of obesity namely, diet and exercise are often the easiest factors to contend with in designing a persuasive obesity intervention. The

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research is clear on the parameters for a diet and exercise regimen that helps obesity sufferers lose weight: eat more fruits and vegetables, eat less junk food, and exercise more. In this respect, mobile obesity interventions are following the lead set by traditional obesity interventions. While personalization well represented, tailoring is less so, indicating again that a focus on individual users, rather than communities or groups to which the users belong. A potential improvement for future mobile interventions is greater use of simulation, which can help users see the cause-and-effect nature of their habits through visually appealing graphics or games.

Dialogue support persuasive features similarly well represented in current mobile obesity interventions. Again, this may be due to mobile interventions simply following the lead of traditional interventions, which backed by extensive evidence regarding how to present obesity information to sufferers effectively.

Only three interventions utilized similarity, which could decrease their effectiveness. Oinas-Kukkonen and Harjumaa [15] to be important because users are more easily persuaded when they perceive systems are similar to themselves in a meaningful way, whether this is language, vernacular, or personality argue the design feature of similarity. In traditional obesity interventions, similarity may take the form of mimicking, in which a person mirrors the way another person speaks to establish an easy rapport, which makes persuading the user easier.

Artificial intelligence presents a pathway for mobile interventions to make full use of similarity to appeal to wide swaths of users, but current interventions have so far shied away from this method, aside from Stein et al. [20]. Bender et al. [4],[5] also used similarity, but in a real world setting, in which the vernacular specific to Filipino-Americans used extensively throughout the interventions. This may be an interesting path for future research, as it can help increase the intervention's credibility to its users.

Social Support persuasive features lagged behind the other two categories. This is surprising, as mobile interventions should be able to provide more social support given the lack of logistical or geographic limitations, as in traditional interventions. The paucity of social support features explained by the lack of consensus on the roles of cooperation, competition, and social facilitation with respect to obesity. While some users may motivated by competition, some may prefer cooperation. More research needs to done on whether these three features are being left out due to a lack of impact, a technological difficulty in implementation, or a combination of both. The lack of Social Support features in the reviewed studies may indicate a gap in the literature for obesity interventions that treat users as members of specific communities, rather than discrete individuals.

3.5. Limitations

The review included nine studies within the last five years. The scholarly field of mobile interventions for obesity is emerging, and the state of the literature continues to evolve with each year. Because the study is limited to articles published in the past five years, current trends may over-represented such as smartphone apps while less popular options today, such as SMS messaging, chatbots, and the like, are under-represented. As the field is relatively new, it is yet unknown what the mobile intervention for obesity of the future will bring.

The articles are also limited to those published in English. Only five online databases searched, but these databases chosen specifically because they contained the most relevant articles for inclusion.

4. CONCLUSION

The review of the literature on persuasive features utilized by current mobile interventions for obesity revealed that Primary Task Support was the most well represented PSD category among current mobile interventions for obesity. This is not surprising, as this category has been popular among traditional obesity interventions. Dialogue Support was represented to a lesser degree, while Social Support was least represented. As mentioned in the introduction, treating obesity holistically requires disrupting the interaction between obesity's personal, environmental, and emotional factors. The lack of Social Support among the reviewed studies indicates that mobile interventions for obesity are focusing more on individuals rather than communities.

Future research needs to be focus on whether the lack of Social Support features among current mobile obesity interventions warranted. While obesity interventions geared for individuals may be effective for users who may have higher levels of self-efficacy or conscientiousness, other users may benefit from the convenience of Social Support features accessed through mobile technology.

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Obesity must be treated holistically, that is, based on one's personal, environmental, and emotional factors. Current interventions for obesity focus too much on personal factors.

This explains why many sufferers struggle with obesity all their lives. This is the reason why some sufferers can exercise and eat healthy for short periods, but gain more weight in the coming years. Obesity has not fallen but has risen in the last few decades, despite the advent of new technologies and methodologies for tackling the issue.

This is the research on the healthcare side. In the SLR, we used the PSD model to find out which persuasive design features are most and least represented among mobile obesity interventions, in order to see potential gaps in current designs.

We found that current mobile obesity interventions have strong primary task and dialogue support. We also found that social support is much less supported, despite persuasive design research that stated social support is vital in creating user engagement.

This is the research on the IT side. Given these facts, what we know are three things: (1) there are many mobile obesity interventions, (2) obesity rates are still not falling, (3) mobile obesity interventions have strong primary task and dialogue support, and weak social support. Because obesity must be treated holistically, (3) is especially concerning.

To summarize For the IT side, we know that the gap is the lack of social support in current mobile obesity interventions. Social support is vital for the persuasive systems design because: the more kinds of support in a system, the higher user engagement is. The higher user engagement is, the higher their compliance to the intervention.

What this means for mobile obesity interventions is that, to become effective, they must be able to engage users. Which requires social support according to PSD.

For the health side, we know that the gap is the lack of holistic treatment for obesity, as evidenced by the rising obesity rates. We also know

Question on gap 1: This is still a research on individuals. Social support only means a way for app users to communicate, compete, and cooperate within the app. It is a persuasive design component to increase engagement.

Question on gap 2: Social support does not mean group intervention. According to the PSD, it only refers to the means with which app users can derive support or information from other app users. Think of a social media game where there are public leaderboards, group challenges, member forums, etc...

Social support is important because the PSD model (and the research that generated it) suggest that app users need social interaction to be fully engaged with the app. This is for the IT side.

In terms of obesity, this means that current mobile obesity interventions may not be treating obesity holistically if social support is lacking. We also know that obesity has personal, environmental, and emotional factors. We found in the SLR that current obesity interventions overly focus on personal factors. We also know that if obesity intervention users do not comply 100% with their intervention, they will fail to overcome obesity.

So how do we convince them to comply 100%? By ensuring that all the dimensions mentioned in the PSD is accounted for (except for system credibility, as mentioned in the SLR.) when we design and develop mobile obesity interventions.

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Table 2. Persuasive Design Features Utilized

	Article Number:	1	2	3	4	5	6	7	8	9
Primary Task Support										
Rehearsal		X	X			X		X		
Simulation		X	X							
Self-monitoring		X	X	X	X	X	X	X	X	X
Personalization		X	X	X	X	X	X	X	X	X
Tailoring		X	X						X	X
Tunneling		X	X	X	X	X		X	X	
Reduction		X	X	X	X	X		X	X	
Dialogue Support										
Social Role		X	X		X		X		X	
Liking		X	X		X	X	X	X	X	X
Similarity		X	X						X	
Suggestion		X	X	X	X	X	X	X	X	
Reminders		X	X	X	X	X	X	X	X	
Rewards		X	X		X	X		X		
Praise		X	X			X			X	
Social Support										
Recognition		X	X		X	X		X		
Competition		X	X		X	X		X		
Cooperation					X					
Social Facilitation					X	X		X		
Normative Influence		X	X		X			X		
Social Comparison		X	X		X	X		X		
Social Learning		X	X		X	X		X		

Table 3. PSD Model (Oinas-Kukkonen & Harjumaa, 2009).

Category	Persuasive Design Featured	Definition
Primary Task Support	Rehearsal	System assists users to rehearse target behavior
	Simulation	Reveals cause and effect regarding target behavior
	Self-monitoring	Should allow users to monitor their performance
	Personalization	Should offer user-specific content
	Tailoring	Must offer group-specific content
	Tunneling	Must guide users toward target behavior
	Reduction	Must have the minimum amount of steps toward target behavior
Dialogue Support	Social Role	System engenders a social tone with user
	Liking	Must appeal to users
	Similarity	Must mimic users
	Suggestions	Must offer suggestions
	Reminders	Must remind users of target behavior
	Rewards	Must offer rewards of some kind to motivate target behavior
	Praise	Must praise user when target behavior is accomplished
System Credibility Support	Verifiability	System must be able to verify content with external sources
	Third-Party Endorsement	Must be endorsed by outside sources
	Authority	Must refer to authorities
	Real-World Feel	Must disclose the individuals behind the content
	Surface Credibility	Must appear to users as competent and truthful
	Expertise	Must offer information that proves system's competence
	Trustworthiness	Must offer objective information
Social Support	Recognition	System must acknowledge users who accomplish target behavior
	Competition	Must allow users a forum to compete with one another
	Cooperation	Must allow users a forum to cooperate with one another
	Social Facilitation	Must be able to separate users who perform target behavior from others
	Normative Influence	Must be able to gather people with similar goals, and persuade them toward similar norms
	Social Comparison	Must provide users the ability to compare their performance to others'
	Social Learning	Must provide users ability to learn from others

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