Zoom Exhaustion & Fatigue Scale

Fauville, G.[1], Luo, M.[2], Queiroz, A. C. M.[2,3], Bailenson, J. N.[2], & Hancock, J.[2]

[1]Department of Education, Communication and Learning, University of Gothenburg, Sweden
[2]Department of Communication, Stanford University, USA
[3]Lemann Center, Stanford University, USA

Abstract

In 2020, video conferencing went from a novelty to a necessity, and usage skyrocketed due to shelter-in-place throughout the world. However, there is a scarcity of academic research on the psychological effects and mechanisms of video conferencing, and scholars need tools to understand this drastically scaled usage. The current paper presents an empirical creation and validation of the Zoom Exhaustion & Fatigue Scale (ZEF Scale). In one qualitative study, we developed a set of interview prompts based on previous work on media use. Those interviews resulted in the creation of 49 survey items that spanned several dimensions. We administered those items in a survey of 395 respondents and used factor analyses to reduce the number of items from 49 to 15, revealing five dimensions of fatigue: general, social, emotional, visual, and motivational fatigue. Finally, in a scale validation study based on 204 respondents, we showed the reliability of the overall scale and the five factors and demonstrated scale validity in two ways. First, frequency, duration, and burstiness of Zoom meetings were associated with a higher level of fatigue. Second, fatigue was associated with negative attitudes towards the Zoom meetings. The scale is available for download at http://comm.stanford.edu/ZEF.

Keywords: video conferences, scale development and validation, fatigue

In March 2020, the World Health Organization declared COVID-19 a pandemic, leading to the declaration of a public health emergency (WHO, 2020). Public health measures, such as social distancing, quarantine, and closing places of social contact (e.g., schools and businesses) were adopted by governments around the world to slow down the spread of the virus (Nussbaumer-Streit et al., 2020). As a consequence, regular activities individuals usually performed outside of their home had to be conducted at home. For example, Bick and colleagues (2020) showed a dramatic increase in the percentage of the US workforce that worked entirely from home, rising from 8.2% in February 2020 to 35.2% in May 2020.

With individuals sheltered at home and trying to remotely conduct their daily activities (Nguyen et al., 2021), video conferencing has become a crucial tool for education (Lowenthal et al., 2020), healthcare (Feijt et al., 2020), and business (Bloom et al., 2021). A prime example is the rapid rise in the use of Zoom, a video conferencing app, from approximately 10 million daily Zoom meeting participants in December 2019 to 200 million in March 2020 and 300 million in April 2020 (Iqbal, 2020; Chawla, 2020).

This thirty-fold increase in video conferences may be part of a growing concern about exhaustion, with the term “Zoom Fatigue” catching on quickly in the popular media. To our knowledge, there is little empirical research examining the psychological effects of this uptick in Zoom usage. Early research (Hinds, 1999) demonstrated that video conferencing increased cognitive load, compared to voice calls. Moreover, Bailenson (in press) outlines four possible explanations for nonverbal causes of Zoom Fatigue: extraordinary amount of eye gaze at a close distance, limited physical mobility, constant viewing of self-video, and increased cognitive load for senders and receivers. However, to test these hypothetical causes, it is important to create a

rigorous scale to measure fatigue associated with video conferencing. Although objective outcomes such as behavioral and physiological measures are generally considered more reliable than self-report measures, a reliable and valid questionnaire is an obvious starting point, and has benefits in terms of scalability and ease of administering.

Given that the ubiquity of the Zoom platform in video conferences has resulted in genericization, with many using the word "Zoom" as a verb to replace video conferencing, similar to "Googling," we will use the term Zoom Fatigue to refer to fatigue experienced during or after video conferencing with any platform. For this purpose, we define *Zoom fatigue as a feeling of exhaustion from participating in video conference calls*. In the present paper, we develop the Zoom Exhaustion & Fatigue Scale (ZEF Scale).

Overview of Studies

The goal of the current research is to design and test a scale to measure Zoom Fatigue. The scale development process involves three phases, guided by the best practices for scale development by Boateng and colleagues (2018): Item development, scale development and scale evaluation. Table 1 outlines the five studies from the current project, and how they mapped onto this framework.

Table 1

Scale Development Overview: Five Studies Across the Three Phases

Phase	Study	Description	Sample size (*N*)	Sample
Item generation	I	Literature review & interviews	10	Convenience sample
Scale development	II	Pre-testing of items	52	University research pool
	III	Scale administration	395	Amazon Mechanical Turk
Scale evaluation	IV	Test of reliability	104	University research pool & Lucid
	V	Test of dimensionality & validity	204	Convenience sample

Item Generation

Study I: Literature Review and Interviews

The first step of scale development is to define a domain of interest and generate items that measure different aspects of the defined domain. Study I aims to generate a large and broad range of potential items for the ZEF Scale that will tap into different dimensions of Zoom fatigue. To this end, we combined deductive and inductive methods by drawing on theoretical insights from a literature review and exploring people's lived experience of Zoom fatigue from semi-structured interviews.

Method

We created a large pool of potential Zoom fatigue items based on prior literature, the researchers' own experience, and existing fatigue scales, such as the Multidimensional Fatigue Inventory (Smets et al., 1995) and social media fatigue scale (Bright, Kleiser, & Grau, 2015). Next, we conducted interviews with 10 heavy video conference users (5 women and 5 men) to identify additional factors that have not been covered in the proposed scale.

Interviewees were between 20 to 59 years old (M = 37.4, SD = 13.8) and included the following racial/ethnic demographics: three African or African-American or Black, three White, one Hispanic or LatinX, and three participants identifying with more than one race. The lead author conducted 10 one-on-one interviews online, with an average duration of 43 minutes (*min* = 23, *max* = 70, SD = 13.3). Participants were compensated with $30 Amazon gift cards. Transcripts of the interviews were created using the software *Otter.ai* and then anonymized. In line with IRB guidelines, audio recordings were destroyed after the study.

At the beginning of each interview, the researcher reiterated the goal of the study and explained how the interview would be conducted. The researcher shared her screen and presented a series of slides. Each slide included 4 to 5 questions designed to capture a specific dimension of Zoom fatigue (e.g., mental fatigue, physical fatigue). For each slide, the participants were asked to (1) think about how the questions worked together around a given aspect of Zoom fatigue, (2) suggest items that could be removed, (3) comment on the clarity of each item. Participants were also prompted to share their own video conferencing experiences. We followed Willis (2005)'s strategy to conduct two rounds of interviews. We reviewed the transcripts of the first 5 interviews and revised the initial Zoom fatigue items based on the feedback. The second round of interviews followed the same procedure to test the revised set of questions with the other 5 participants. After ten interviews, researchers decided to stop as they started to observe similar feedback - an indicator of content saturation.

Results

An in-depth literature review and interviews produced a pool of 49 items gathered in 9 thematic constructs related to Zoom fatigue. This large number was consistent with the recommended number of the initial pool of questions (i.e., two to five times as large as the items

in the final scale; Kline, 1993; Schinka et al., 2012). The initial scale included nine fatigue-related constructs. The first five constructs were adapted from the Multidimensional Fatigue Inventory (Smets, et al., 1995). *General fatigue* (1) refers to the superordinate experience of being tired (e.g., feeling drained); *physical fatigue* (2) refers to one's physical sensation related to tiredness (e.g., feeling physically only able to do a little); *mental fatigue* (3) refers to cognitive symptoms related to fatigue (e.g., feeling hard to concentrate on things); *reduced motivation* (4) refers to a lack of motivation to start an activity (e.g., dread having to do things); *reduced activity* (5) refers to a tendency to be less active (e.g., get little done). *Visual fatigue* (6) is defined by the National Research Council Committee on Vision as "any subjective visual symptom or distress resulting from use of one's eyes" (1983, p.153) and is measured by Tyrrell & Leibowitz (1990) with items such as "my vision seems blurry". *Vocal fatigue* (7) refers to issues related to speaking, including the throat, and was adapted from the Vocal Fatigue Index (VFI) (Nanjundeswaran et al., 2015) with items such as "My voice feels tired when I talk more". *Emotional fatigue* (8), defined as "the state of feeling overwhelmed, drained and used up" (Maslach, 1982, p.2), occurs after interactions with other people (Wright & Cropanzano, 1998) and includes items based on emotional symptoms related to fatigue, such as moodiness and irritability (Department of Health & Human Services, 2015). *Social fatigue* (9) refers to feelings of wanting to be alone, which is derived from the interview and researchers' experiences.

Scale Development

In this phase, our goal was to statistically examine the 49 created items, reduce items, and test models of the ZEF scale.

Study II: Pre-testing of items

We conducted this pilot study to assess the readability of the 49 items created in Study I. The 49 items were piloted with 52 Stanford students to get additional feedback on the survey experience as a whole. The survey was administered through the Qualtrics platform. Participants (50% female, 50% male) were between 18 and 27 years old (M = 20.35, SD = 1.81). The distribution of ethnic backgrounds was: 40.4% of White (n = 21), 15.4% of Asian or Asian-American (n = 8), 13% of African or African-American or Black (n = 7), 3.9% of Hispanic or LatinX (n = 2), 9.6% Native Hawaiian or Pacific Islander (n = 5), 17.3% identifying with more than one race (n = 9).

In addition to the 49 fatigue questions, participants were asked to provide additional comments on the clarity and readability of items and to indicate their use frequency of video conferencing. Since some of our sample used video conferencing less than once a day, we decided in the remaining studies to focus on people who use video conferences at least once a day to increase the likelihood of capturing one's Zoom fatigue experience. Therefore, in future studies, we added a screening question at the beginning of the survey to reflect this change, and only included participants who attend video conferences on a typical day.

Study III: Scale Administration

The purpose of this study was to reduce the number of items and perform confirmatory factor analyses (CFA) to test our proposed structural model.

Participants

A total of 395 participants were recruited online through Amazon's Mechanical Turk worker system. This sample size was consistent with the recommended size in prior literature (Comrey, 1988; Guadagnoli & Velicer, 1988). Each participant was compensated $2.50 for completing the questionnaire. The sample included 37% female (n = 148), 62% male (n = 243)

and 1% of participants who identified neither as male nor female (n = 4). The age ranged from 18 to 70 years old (M = 30.05, SD = 9.13). The distribution of race/ethnic backgrounds was: 56.7% of White (n = 224), 16% of Asian or Asian-American (n = 63), 10.4% of African or African-merican or Black (n = 41), 8.1 % of Hispanic or LatinX (n = 32), 4.5% identifying with more than one race (n = 18), 2% declined to answer (n = 8), 1.5% Middle Eastern (n = 6), 0.5% Native Hawaiian or Pacific Islander (n = 2), 0.25%, and one Indigenous or Native American participant (n = 1). Forty-five percent of the sample reported using video conferences once a day (n = 176) whereas 55% reported using video conferences multiple times a day (n = 219).

Procedure

Upon consenting to participate, participants were initially asked how often they used video conferences. A minimum of attending video conferences daily was required to proceed with the study. Participants who failed the attention check questions or used video conferences less than daily were removed from data analysis, leaving a final sample of 395.

Participants were then introduced to the 49-item ZEF scale (see Appendix 1) and asked to indicate their level of fatigue on a five-point Likert-type scale from 1 = “Not at all” to 5 = “Extremely”. The order of the items was randomized.

Results

All analyses were conducted in statistical language in R software (version 1.3.1093). First, item reduction analysis was performed to develop a parsimonious scale with internally consistent items (Thurstone, 1947; Boateng et al., 2018). We followed the Classical Test Theory (CTT) to exclude items based on their inter-item and item-total correlations. Out of the 49 items, 8 were removed due to their low item-total correlation (<.3). Then, we calculated the mean inter-item correlation to test whether the remaining items were reasonably homogeneous while

containing sufficient unique variance. The mean inter-item correlation was within the acceptable range from .2 to .4 (r = .33).

Second, we conducted a series of iterative second-order confirmatory factor analyses (CFA) to test our theoretical structural model. The predicted nine-factor model with the remaining 41 items was tested. In the first CFA, 18 items with loadings lower than .7 were removed. Since all the items from vocal fatigue were removed, this construct was removed as well. A new model with 8 constructs and 24 items was tested. Nine additional items were removed due to low factor loadings and the 15 remaining items focused on 5 constructs: general, visual, social, motivational, and emotional fatigue. The remaining two items from the general fatigue construct (gen_1 and gen_5) were merged with the remaining item from the mental fatigue construct (men_1), creating the construct general fatigue. The two remaining items from the reduced motivation construct (redmot_2 and redmot_4) were merged with the only remaining item from the reduced activity construct (redac_5), creating the construct of motivational fatigue. This resulted in the following CFA model with good fit metrics: CFI = .942, TLI = .929, RMSEA = .086 and SRMR = .039, X^2 (85) = 332.1. Finally, Cronbach's alphas were calculated for each of the 5 remaining constructs, which indicated good reliability (all a > .8; see Table 2).

Table 2

Descriptive Statistics, Factor Loadings and Cronbach Reliability of the 15 Items in the ZEF Scale

Constructs	Items	Std. loading	Construct loading	α	*Mean*	*SD*
General Fatigue	I feel tired	.81	.99	.87	2.77	1.06
	I feel exhausted	.85				
	I feel mentally drained	.81				
Visual Fatigue	my vision gets blurred	.80	.67	.88	2.30	1.09
	my eyes feel irritated	.87				
	I experience pain around my eyes	.86				
Social Fatigue	I avoid social situations	.72	.93	.81	2.58	1.66
	I just want to be alone	.81				
	I need time by myself	.76				
Motivational Fatigue	I dread having to do things	.78	.95	.86	2.50	1.10
	I don't feel like doing anything	.82				
	I often feel too tired to do other things	.84				
Emotional Fatigue	I feel emotionally drained	.81	1.00	.82	2.35	1.04
	I feel irritable	.75				
	I feel moody	.76				

Note. The prompt for the items was "After video conferencing…"

With the reduction of the scale from 49 to 15 items, we reworded the items to become individual questions with construct-specific response options. These 15 items across 5 constructs constitute the final ZEF Scale and are presented in Table 3. All items are measured on 5- point Likert-scale ranging from 1 = *"Not at all"*, 2 = *"Slightly"*, 3 = *"Moderately"*, 4 = *"Very"* to 5 = *"Extremely"* except for the two frequency questions (marked with asterisks) from 1 = *"Never",* 2 = "*Rarely*", 3 = "*Sometimes*", 4 = "*Often*" to 5= *"Always"*.

Table 3

Survey Questions for the ZEF Scale

Constructs	Questions
General Fatigue	How tired do you feel after video conferencing?
	How exhausted do you feel after video conferencing?
	How mentally drained do you feel after video conferencing?
Visual Fatigue	How blurred does your vision get after video conferencing?
	How irritated do your eyes feel after video conferencing?
	How much do your eyes hurt after video conferencing?
Social Fatigue	How much do you tend to avoid social situations after video conferencing?
	How much do you want to be alone after video conferencing?
	How much do you need time by yourself after video conferencing?
Motivational Fatigue	How much do you dread having to do things after video conferencing?
	How often do you feel like doing nothing after video conferencing? *
	How often do you feel too tired to do other things after video conferencing? *
Emotional Fatigue	How emotionally drained do you feel after video conferencing?
	How irritable do you feel after video conferencing?
	How moody do you feel after video conferencing?

Scale Evaluation

Study IV: Test of Reliability

Study IV aims to assess the internal consistency of the revised version of the ZEF scale using independent samples.

Participants

Participants were recruited from the Lucid platform - an aggregator of survey respondents from multiple sources – and a student research pool at Stanford University. Participants were qualified to answer the survey if they reported using video conferences more than “once a day” in a screening question. Participants who failed the attention check question were directly

terminated and no data was recorded for them. A total of 114 participants took part in this study (47 students, 57 recruited from Lucid). The participants (58% female, 41% male, 1% identifying neither as female nor male) were between 18 and 62 years old (M = 29.35, SD = 11.45). The distribution of race or ethnic backgrounds among participants was as follows: 47% of White (n = 49), 15.4% of African or African-American or Black (n = 16), 19.2% of Asian or Asian-American (n = 20), 7.7% of Hispanic or LatinX (n = 8), 7.7% of participants identifying with more than one race (n = 8), 1.9% of Middle Eastern (n = 2) and 1% of Native Hawaiian or Pacific Islander (n = 1). Participants who failed the two attention check questions were removed from the data analysis.

Results

The Cronbach's alphas were calculated for each of the five constructs of fatigue (each including three items). The reliability for each construct was above .8 (general fatigue: α = .88, visual fatigue: α = .88, social fatigue: α = .84, motivational fatigue: α = .83, emotional fatigue: α = .86), indicating a good scale reliability.

The ZEF Score is the averaged rating across the 15 fatigue items and showed high reliability (α = .95), which is significantly correlated with each of the five constructs of the scale (see Table 4 for the bivariate correlations).

Table 4

Means, SDs, and Bivariate Correlations Among the ZEF Score and 5 Constructs of Zoom Fatigue

Fatigue	1.	2.	3.	4.	5.	6.	*Mean*	*SD*
1. ZEF Score							2.99	.97
2. General	.92***						3.22	1.08
3. Emotional	.92***	.81***					2.85	1.13
4. Visual	.85***	.73***	.70***				2.88	1.23
5. Motivational	.88***	.85***	.78***	.68***			3.18	1.04
6. Social	.79***	.61***	.74***	.57***	.58***		2.89	1.13

Note. $N = 104$, ZEF Score = average scoring of 15 items.
*** $p < .001$ (two-tailed)

Study V: Test of Dimensionality and Validity

The final study aims to assess the validity of the ZEF scale. We investigated if Zoom fatigue is correlated to two theoretically similar constructs – frequency of use and attitude towards video conferencing – to evaluate the scale's convergent validity. Prior literature suggested a positive association between fatigue and the use of the given technology, such as the duration of internet use (Dol, 2016) and social media overuse (Sanz-Blas, Buzova, & Miquel-Romero, 2019). Therefore, we predicted that longer and more frequent use of video conferencing may be associated with higher levels of fatigue. We also predicted that individuals who feel more fatigued will have more negative attitudes towards the medium than those who feel less fatigued. Although feelings of fatigue may not necessarily correspond to negative affect (i.e., a rewarding day of work or a long walk can be tiring and positive at the same time), our qualitative interviews demonstrated that people who felt overusing Zoom tend to view video conferencing negatively.

Participants

A total of 204 participants were recruited through the snowball sampling technique. Members of the current research team distributed the online survey via email to their students and colleagues, who were in turn referred to their networks of video conferencing users. Participants (68% female, 30% male, 1.5% identifying neither as female nor male, 1% declining to answer) were between 18 and 75 years old (M = 38.3, SD = 10.7). The distribution of ethnic backgrounds was: 61.7% of White (n = 126), 15.7% of Asian or Asian-American (n = 32), 4.9% of Hispanic or LatinX (n = 10), 1.6% of Middle Eastern (n = 3), 10.8% of participants identifying with more than one race (n = 22), 3.4% of African or African-American or Black (n = 7), and 2.1% declined to answer (n = 4). Participants who failed the two attention check questions were removed from the data analysis.

Measures

In addition to the 15-item multidimensional ZEF scale (see Table 3 for all items), attitudes toward video conferencing, and three measures of the use of video conferencing were also included in the survey.

Attitudes. Attitude toward video conferences was measured on a three-item Likert-scale (i.e., "How much do you like participating in video conferences", "How much do you feel like video conferences are a burden?", and "How much do you enjoy video conferences") ranging from 1 = *"Not at all"* to 5 = *"Extremely"*.

Frequency. Participants were asked to indicate "On a typical day, how many video conferences do you participate in" on a 7-point Likert-scale ranging from 1 = "1" to 7 = "7 and more".

Duration. Participants were asked to indicate "on a typical day, how long does a typical video conference last*"* on a 5-point Likert-scale ranging from 1 = *"Less than 15 minutes"*, 2 = *"15 to 30 minutes"*, 3 = *"30 to 45 minutes"*, 4 = *"45 minutes to an hour"*, and 5 = *"More than an hour"*.

Burstiness. Participants were asked to indicate "on a typical day, how much time do you have between your video conferences?" As frequency, duration and burstiness are used to measure the level of intensity of the video conferences experience, burstiness was reversed coded as less time between meetings indicating high burstiness. The response options range from 1 = *"More than an hour"*, 2 = *"45 minutes to an hour"*, 3 = *"30 to 45 minutes"*, 4 = *"15 to 30 minutes"*, and 5 = "*Less than 15 minutes*".

Results

Factor analysis of the ZEF scale. To test the dimensionality of the scale, a confirmatory factor analysis was firstly used to examine the model's goodness of fit. A second-order 5-factor (i.e., general, visual, social, motivational, and emotional fatigue) model was tested. The model revealed a good fit and supported the 5-factor structure in this diverse adult sample: CFI = .958, TLI = .949, RMSEA = .076 and SRMR = .050, X^2 (85) = 185.17. The loading of each item onto their construct and of each construct onto the ZEF score are presented in Table 5 along with the reliability of each construct and their means and standard deviations.

Table 5

Descriptive Statistics, Factor Loadings, and Cronbach Alphas of the ZEF Scale Items

Fatigue	Item	Std. loading	Construct loading	α	*Mean*	*SD*
General	How tired do you feel after video conferencing?	.85	.97	.90	3.15	.95
	How exhausted do you feel after video conferencing?	.87				
	How mentally drained do you feel after video conferencing?	.89				
Visual	How blurred does your vision get after video conferencing?	.80	.55	.89	2.18	.99
	How irritated do your eyes feel after video conferencing?	.86				
	How much do your eyes hurt after video conferencing?	.90				
Social	How much do you tend to avoid social situations after video conferencing?	.79	.84	.88	2.77	1.10
	How much do you want to be alone after video conferencing?	.87				
	How much do you need time by yourself after video conferencing?	.87				
Motivational	How much do you dread having to do things after video conferencing?	.78	.91	.85	2.99	.96
	How often do you feel like doing nothing after video conferencing?	.81				
	How often do you feel too tired to do other things after video conferencing?	.85				
Emotional	How emotionally drained do you feel after video conferencing?	.83	.90	.88	2.57	1.03
	How irritable do you feel after video conferencing?	.86				
	How moody do you feel after video conferencing?	.87				

Note. $N = 204$

Analysis of reliability. Similar to Study IV, the ZEF Score and each factor of the ZEF scale are significantly correlated, suggesting high internal reliability of the scale (see Table 6 for the bivariate correlation matrix).

Table 6

Means, SDs, and Bivariate Correlations Among the ZEF Score and Each Construct of Zoom Fatigue

Fatigue	1.	2.	3.	4.	5.	6.	*Mean*	*SD*
1. ZEF Score							2.73	.84
2. General	.90***						3.15	.95
3. Emotional	.90***	.79***					2.57	1.03
4. Visual	.67***	.49***	.52***				2.18	.99
5. Motivational	.86***	.79***	.71***	.42***			2.99	.96
6. Social	.85***	.72***	.72***	.38***	.69***		2.77	1.1

Note. $N = 204$, *** $p < .001$

Scale validity. To assess convergent validity, the correlations between the ZEF Score, which is the average rating of all items on the ZEF scale, video conference attitude, and video conference use were examined. As shown in Table 7, attitude was significantly negatively correlated to the ZEF Score [$r(202) = -.57$, $p < .001$], suggesting that a higher level of Zoom fatigue corresponds to a lower positive attitude toward video conferences. Similarly, consistent with our hypotheses, the ZEF Score was positively correlated to the three measures of video conferencing use: a higher level of fatigue is associated with having more meetings (frequency, r (202) = .23, $p < .005$), longer meetings [duration, $r(202) = .17$, $p < .05$], and the tendency to cluster meetings together without breaks in between [burstiness; $r(202) = .17$, $p < .05$], suggesting high convergent validity.

Table 7

Means, SDs, and Bivariate Correlations Among the ZEF Score and Variables for Validity Tests

	1.	2.	3.	4.	5.	*Mean*	*SD*
1. ZEF Score						2.73	.84
2. Attitude	-.57***					2.7	.80
3. Frequency	.23**	-0.1				2.96	1.67
4. Duration	.17*	-0.07	-.25***			4.03	.73
5. Burstiness	.17*	-0.04	.74***	-0.11		2.89	1.6

Note. $N = 204$; * $p < .05$, ** $p < .01$, *** $p < .001$,

Finally, we used a linear regression to predict the ZEF Score with the three measures of video conferencing use, frequency, duration and burstiness, as predictors. The omnibus model was significant, F (3, 200) = 7.99, $p < .001$, 95% CI [.47, 1.90], adjusted $R^2 = .094$. Controlling for the other two types of video conferences use, both duration ($\beta = .28$, $SE = .08$, $p < .001$) and frequency ($\beta = .16$, $SE = .05$, $p = .002$) were significant predictors of the ZEF Score, whereas burstiness was not significant ($\beta = -.02$, $SE = .05$, $p = .65$). To examine the potential interactions of video conferencing use measures, another linear regression was modeled with a three-way interaction to predict the ZEF Score. A comparison between the full and reduced model suggests a non-significant interaction effect, $F(4, 196) = 1.16$, $p = .33$, 95% CI [-2.37, 2.49].

General Discussion

Current research outlines the process and results of the development and validation of the ZEF Scale (freely available for use). In four studies, which included over 700 participants, we created a scale examining Zoom fatigue and provided initial evidence for the scale validity. The final scale involves 15 items measuring 5 aspects of fatigue experienced in video conferences, which were found reliable across multiple studies. Moreover, the ZEF scale has been validated

by both frequency of video conferencing use and attitudes towards video conferencing. People who have more and longer meetings tend to feel more fatigued than those with fewer and shorter meetings. Moreover, people who feel more fatigued after a video conference tend to have a more negative attitude towards it.

The current research has limitations. First, while we employed a number of strategies to ensure a diverse population of respondents, such as recruiting participants from several sources, some races or ethnic groups were underrepresented. Second, the five dimensions of the scale highly correlate with one another, and thus are likely to be dependent. Finally, the current research did not examine all types of validities, such as predictive validity and discriminant validity.

In addition to a systematic assessment of scale validity, future work could also employ the ZEF scale to examine the potential causes and outcomes of Zoom fatigue. For example, our initial qualitative interview suggested a few potential predictors of Zoom fatigue, such as perceived gaze, self-presentation concerns, and immobility. We plan to empirically test these hypotheses as the next step. Future work could also explore how people in different contexts (e.g., work vs. socializing, size of the video conferencing) or individual differences (e.g., gender, personalities) may experience Zoom fatigue differently. We also want to empirically investigate the cost-benefit ratio of video conferencing, given it is one of the main channels people have for social interaction.

Conclusion

In sum, the present research provides a valid and reliable measure for the Zoom Fatigue that is available to employ by other researchers interested in this field. In the emerging media era, the fact that increasing people have seamlessly integrated Zoom and other video

conferencing technologies into their work and social lives has posed important questions such as when, how, and why Zoom fatigue occurs, as well as how to mitigate the fatigue effectively. We encourage more future work on this topic to advance this new line of research because it will have practical implications on interpersonal communications in video conferences and interface designs of the platforms.

Acknowledgments

This research was partially supported by two National Science Foundation grants (IIS-1800922 and CMMI-1840131) and by the Knut och Alice Wallenbergs Stiftelse #20170440. Moreover, we are thankful for assistance in this research from Jet Toner, Tobin Asher, Sunny Liu and Carlyn Strang.

References

Bailenson, J. N., (in press). Nonverbal overload: A theoretical argument for the causes of Zoom Fatigue. *Technology, Mind, and Behavior.*

Bick, A., Blandin, A., & Mertens, K. (2020). *Work from home after the COVID-19 outbreak.* CEPR Discussion Paper No. DP15000, Available at SSRN: https://ssrn.com/abstract=3650114

Bloom, N., Davis, S. J., & Zhestkova, Y. (2021). *COVID-19 Shifted Patent Applications Toward Technologies that Support Working from Home*. University of Chicago, Becker Friedman Institute for Economics Working Paper No. 2020-133. http://dx.doi.org/10.2139/ssrn.3695191

Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quiñonez, H. R., & Young, S. L. (2018). Best practices for developing and validating scales for health, social, and behavioral research: A Primer. *Frontiers in Public Health*, 6(June), 1–18. https://doi.org/10.3389/fpubh.2018.00149

Bright, L. F., Kleiser, S. B., & Grau, S. L. (2015). Too much Facebook? An exploratory examination of social media fatigue. *Computers in Human Behavior*, *44*, 148–155. https://doi.org/10.1016/j.chb.2014.11.048

Chawla, A. (2020). *Coronavirus (COVID-19) – 'Zoom' application boon or bane*. Available at SSRN: http://dx.doi.org/10.2139/ssrn.3606716

Comrey, A. L. (1988). Factor-analytic methods of scale development in personality and clinical psychology. *American Psychological Association,* 56, 754–61.

Department of Health & Human Services. (2015). *Symptoms of fatigue.* Retrieved February 12, 2021 from: https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/fatigue

Dol, K. S. (2016). Fatigue and pain related to internet usage among university students. Journal

of Physical Therapy Science, 28(4), 1233–1237. https://doi.org/10.1589/jpts.28.1233

Feijt, M., De Kort, Y., Bongers, I., Bierbooms, J., Westerink, J., & Ijsselsteijn, W. (2020). Mental health care goes online: Practitioners' experiences of providing mental health care during the COVID-19 pandemic. *Cyberpsychology, Behavior, and Social Networking*, *23*(12), 860–864. https://doi.org/10.1089/cyber.2020.0370

Guadagnoli, E., Velicer W. F. (1988). Relation of sample size to the stability of component patterns. *American Psychological Association,* 103, 265–75.

Hinds, P. J. (1999). The cognitive and interpersonal costs of video. *Media Psychology, 1*(4), 283–311. https://doi.org/10.1207/s1532785xmep0104_1

Iqbal, M. (2020). *Zoom revenue and usage statistics*. Business of apps. Retrieved February 12, 2021 from: https://www.businessofapps.com/data/zoom-statistics/

Kline, P. A. (1993). *Handbook of Psychological Testing.* 2nd Ed. London: Routledge; Taylor & Francis Group.

Lowenthal, P., Borup, J., West, R., & Archambault, L. (2020). Thinking beyond Zoom: Using asynchronous video to maintain connection and engagement during the COVID-19 pandemic. *Journal of Technology and Teacher Education*, *28*(2), 383–391.

Maslach, C. *Burnout: The cost of caring*. Englewood Cliffs, NJ: Prentice-Hall, 1982.

Nanjundeswaran, C., Jacobson, B. H., Gartner-Schmidt, J., & Verdolini Abbott, K. (2015). Vocal Fatigue Index (VFI): Development and Validation. *Journal of Voice*, *29*(4), 433–440. https://doi.org/10.1016/j.jvoice.2014.09.012

National Research Council Committee on Vision. (1983). *Video displays, work and vision*. Washington, DC: National Academy Press

Nguyen, M. H., Gruber, J., Marler, W., Hunsaker, A., Fuchs, J., & Hargittai, E. (2021). Staying

connected while physically apart: Digital communication when face-to-face interactions are limited. *New Media & Society*, 1461444820985442.

Nussbaumer-Streit, B., Mayr, V., Dobrescu, A. I., Chapman, A., Persad, E., Klerings, I., Wagner, G., Siebert, U., Christof, C., Zachariah, C., & Gartlehner, G. (2020). Quarantine alone or in combination with other public health measures to control COVID-19: A rapid review. *Cochrane Database of Systematic Reviews*, 4, CD013574. https://doi.org/10.1002/14651858.CD013574.pub2

Sanz-Blas, S., Buzova, D., & Miquel-Romero, M. J. (2019). From Instagram overuse to instastress and emotional fatigue: the mediation of addiction. *Spanish Journal of Marketing - ESIC*, *23*(2), 143–161. https://doi.org/10.1108/SJME-12-2018-0059

Smets, E. M. A., Garssen, B., Bonke, B., de Haes, J. (1995). The multidimensional fatigue inventory (MFI) psychometric qualities of an instrument to assess fatigue. *Journal of Psychosomatic Research*, *39*(5), 315–325. https://doi.org/10.1016/0022-3999(94)00125-O

Schinka, J. A., Velicer W. F., Weiner I. R. (2012). *Handbook of Psychology*. Vol. 2, Research Methods in Psychology. Hoboken, NJ: John Wiley & Sons, Inc.

Thurstone, L. (1947). *Multiple-Factor Analysis.* Chicago, IL: University of Chicago Press

Tyrrell, R. A., & Leibowitz, H. W. (1990). The relation of vergence effort to reports of visual fatigue following prolonged near work. *Human Factors*, *32*(3), 341–357. https://doi.org/10.1177/001872089003200307

Willis, G.B. (2005). *Cognitive Interviewing: A Tool for Improving Questionnaire Design*. Thousand Oaks, CA: Sage Publications.

Wright, T. A., & Cropanzano, R. (1998). Emotional exhaustion as a predictor of job performance and voluntary turnover. *Journal of Applied Psychology*, 83(3), 486–493.

https://doi.org/10.1037/0021-9010.83.3.486

World Health Organisation. (2020). *Joint ICAO- WHO Statement on COVID-19. World Health Organisation.* Retrieved on February 12, 2021 from: https://www.icao.int/Security/COVID-19/Pages/Statements.aspx

Appendix 1

Table 1

Original 49 Items Tested

After participating in a video conference: (not at all - Slightly - Moderately - Very - Extremely)
General Fatigue
gen_1: I feel tired gen_2: I feel rested (Reversed) gen_3: I feel energized (Reversed) gen_4: I feel refreshed (Reversed) gen_5: I feel exhausted gen_6: I need to take a nap
Physical Fatigue
phy_1: can take on only a little physically phy_2: I can take on a lot physically (Reversed) phy_3: I feel restless phy_4: my back hurts phy_5: my neck hurts phy_6: my body feels tired
Mental Fatigue
men_1: I feel mentally drained men_2: I can concentrate well (Reversed) men_3: it takes a lot of effort to concentrate on my next tasks men_4: my thoughts easily wander men_5: I am able to think clearly (Reversed)
Visual Fatigue
vis_1: I often get a headache vis_2: my vision gets blurred vis_3: my eyes feel fine (Reversed) vis_4: my eyes feel irritated vis_5: I experience pain around my eyes vis_6: I experience a burning or pricking sensation in the eyes

Vocal Fatigue
voc_1: I feel like talking (Reversed) voc_2: my voice feels tired voc_3: I tend to generally limit my talking voc_4: my throat aches with voice use voc_5: my voice feels strong (Reversed) voc_6: my voice gets hoarse voc_7: it feels like work to use my voice
Social Fatigue
soc_1: I avoid social situations soc_2: I just want to be alone soc_3: I crave seeing other people (Reversed) soc_4: I feel like engaging with other people is effortless (Reversed) soc_5: I need time by myself
Reduced Activity
redac_1: I feel very active (Reversed) redac_2: I feel like I can do a lot (Reversed) redac_3: I get little done redac_4: I need to take a break redac_5: I often feel too tired to do other things
Reduced Motivation
redmot_1: I feel like doing all sorts of things (Reversed) redmot_2: I dread having to do things redmot_3: I feel like making plans (Reversed) redmot_4: I don’t feel like doing anything
Emotional Fatigue
emo_1: I feel emotionally drained emo_2: I feel irritable emo_3: I feel moody emo_4: I feel excited (Reversed) emo_5: I feel happy (Reversed)