

# FAST AND EFFECTIVE STRESS RELIEF IN WOMEN THROUGH BRAINWAVE-ENTRAINMENT TECHNOLOGY IN PANDEMICS

Research Paper

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## Abstract

*During crisis situations such as the COVID-19 pandemic, women are comparatively more stressed than men. Potential female stressors are complex (e.g., childcare workload, fear of social rejection) pushing women to a breaking point. Conventional methods for stress relief (yoga and meditation) may work to mitigate this situation, however they need commitment and time to unfold. Research of Brainwave Entrainment (BWE) reports fast effects on reducing stress, anxiety and depression. This study tests the ability of BWE to relief stress and increase concentration so that women may cope with stressors while still being able to concentrate. Using a survey, we found significant support for stress relief, increase in concentration and a trend that women profited to a higher extend than men. BWE-users retrospectively reported e.g., a 65% increase of relaxation and calmness, a 47% increase in patience at work and a 46% decrease of difficulties to follow conversations.*

*Keywords: Brainwave Entrainment-technology, Stress, Concentration, Wellbeing, Gender.*

## 1 Introduction

The COVID-19 pandemic is challenging all of us (Van Bavel et al., 2020). Across the world, families experience a new range of stressors threatening their safety, health, and economic wellbeing (Brown et al., 2020). These stressors include the own health risk as well as that of loved ones, economic as well as lifestyle disruptions, hopelessness and low trust in societal response. Although COVID-19 is just one global public health challenge, it will likely have long-term negative effects impacting on mental health and wellbeing in particular (O'Connor et al., 2020) and with that effect on today's families (Brown et al., 2020) and workforce (Burdorf et al., 2020; Tan et al., 2020).

Yet, COVID-19 is likely to impact differently on men and women (Alon et al., 2020). For the realm of science, Goulden et al., (2011) investigated why it is so difficult to keep women in the science pipeline. The authors report that marriage and childbirth account for the largest leaks between PhD receipt and tenure acquisition. Specifically, married mothers are 35 percent less likely to receive a tenure-track after the receipt of their PhD than married fathers. Obviously, COVID-19 has challenged everybody in academia. Researchers experienced a sudden transition to remote teaching, changing grading systems, and complicated access to research resources (Malisch et al., 2020). Furthermore, additional shifts in the household labor, childcare, eldercare, and physical confinement have strained faculty's mental health and reduced time for working (Malisch et al., 2020). Yet, while additional shifts in academia are likely to be experienced gender independently, it is very likely that shifts related to household labor and childcare are rather experienced by females than by male faculty members (Gabster et al., 2020). While this example relates to academia, additional shifts in household labor and childcare are likely to impact women in any profession (Alon et al., 2020). The increase in the traditional double burden put working mothers in a difficult situation, forcing them to reduce working hours or even to temporarily quit their jobs (Blaskó et al., 2020). For the scientific realm, early data already shows that COVID-19 significantly

affects women's publishing rather than men's (Amano-Patiño et al., 2020; Andersen et al., 2020). Also, for other professions, first results show the difficult position of women in their job and the widening gender employment gap among parents (Bowes et al., 2020; Qian and Fuller, 2020).

The European Commission has already acknowledged the importance to support women in the COVID-19 situation for reducing the gender employment gap (Blaskó et al., 2020) and emphasizes measurements such as unstereotyping gender roles (Bhatia, 2020). While this is a promising approach its effects may require too long to prevail. While waiting for such a strategy to succeed, working mothers also need instant help for reducing stress and increase their wellbeing and concentration in order to cope with their daily life. Traditionally, yoga and meditation were means to reduce stress and increase wellbeing and concentration (Chiesa and Serretti, 2009; Chong et al., 2011). Yet, additional time needs to be invested for yoga or meditation exercises to gain first effects. In times of COVID-19 access to meditation or yoga classes is often restricted and additional time for working mothers is rare so that measurements are required, which can more easily be integrated into daily life.

We think that Brainwave Entrainment (BWE) has the potential to instantly and lastingly help to foster relaxation, wellbeing and concentration with very little or no additional time investment. BWE refers to the capacity of the brain to adapt to external stimuli such as auditory beats (Adrian and Matthews, 1934; Neher, 1961; Will and Berg, 2007). Based on the frequency chosen, different functions of the brain are stimulated such as focus or relaxation. BWE has already shown promising results to relief depression, anxiety, stress and to support cognitive abilities such as concentration (Garcia-Argibay et al., 2019; Huang and Charyton, 2008). Although BWE-providers have described how BWE can be applied for scenarios such as stress relief, increase of concentration, deepening the meditation practice and regeneration (Daugis, 2020a), we still do not know for what problems BWE-users intuitively use this technology and what effects they perceive. Neither do we know whether BWE really suits the needs of how females seek relaxation and improve concentration. In this paper, we aim to investigate problems that BWE-users address with this technology and how males and females perceive its effect on stress, concentration and wellbeing. Although BWE has proven to be promising, it remains a tool known to only a few insiders. This is why we seek to initiate a bunch of new IS research areas in traditional realms such as e-Health, telework and e-Learning and in emerging realms such digital wellbeing, positive computing and Neuro-IS.

## **2 Background**

Men and women appear to response to stressors differently (Hamidovic et al., 2020; Liu et al., 2017). Investigating the extent to which stressors effect men and women, Stroud et al., (2002) report results from a laboratory experiment, in which 50 healthy volunteers were randomly assigned to achievement and to social rejection stressors. Achievement stressors, for instance, are situations of failure, or perceived goal blockage, where persons might not be able to show the performance, they intend to. Social rejection stressors can be defined as stressors that are related to other persons, e.g., if one feels rejected by others or excluded from a group. The authors report that although there were no differences in mood ratings, men showed significantly greater cortisol responses (a physiological reaction that indicates stress) to the achievement stressors while women showed greater cortisol responses to social rejection stressors. Based on their results, Stroud et al., (2002) conclude that women are more physiologically reactive to negative interpersonal events than men. These results indicate that mothers may be more psychologically affected in the COVID-19 crisis as they suffer more from negative interpersonal effects due to an increased amount of childcare and household duties next to their work than fathers. As men in contrast to women rather respond to achievement stressors, it is also likely that mothers try to balance the social rejection stressors by prioritizing the family needs above their work achievements. To help females dealing with increasing family stress while further being able to correspond to their work achievements, we investigate the potential of BWE as a strategy to reduce stress and increase concentration in general in section 2.1 and its potential for women in section 2.2.

## 2.1 Brainwave Entrainment

BWE refers to using a periodic stimulus to entrain or synchronize frequency of brainwaves (Adrian and Matthews, 1934; Neher, 1961; Will and Berg, 2007). Depending on the frequency, different functions of the brain are stimulated (Cantor and Evans, 2013; Culbert, 2017; see Figure 1a). For instance, beta waves (13Hz-30Hz) are associated with focus and alertness (Puzi et al., 2013), but can also indicate stress (Mitrpanont et al., 2017). Alpha waves (8-13Hz) are associated with a calm, focused mind while theta waves (4-8Hz) are related to creative thinking. Delta waves (0-4Hz) are associated with deep sleep (Ashtaputre-Sisode, 2016). Against this background, stimulating the appropriate brainwave frequency can lead to a more restful sleep, lowered stress and increased wellbeing (Culbert, 2017). Beyond these general effects, positive effects are reported for stress, depression, anxiety, pain, addiction and hypertension (Aftanas et al., 2016; Garcia-Argibay et al., 2019; Gilula and Kirsch, 2005; Huang and Charyton, 2008; Morse et al., 2011).

BWE can be achieved using auditory, visual or haptic stimuli (Huang and Charyton, 2008). In particular, auditory stimuli have gained increasing interest as they can easily be applied. Yet, a major problem with auditory beats is that half of the useful brainwave frequencies (0.3-40Hz) are below the human hearing range (20-20.000Hz). Effective technologies that address the whole spectrum are binaural and isochronic beats (see Figure 1b).

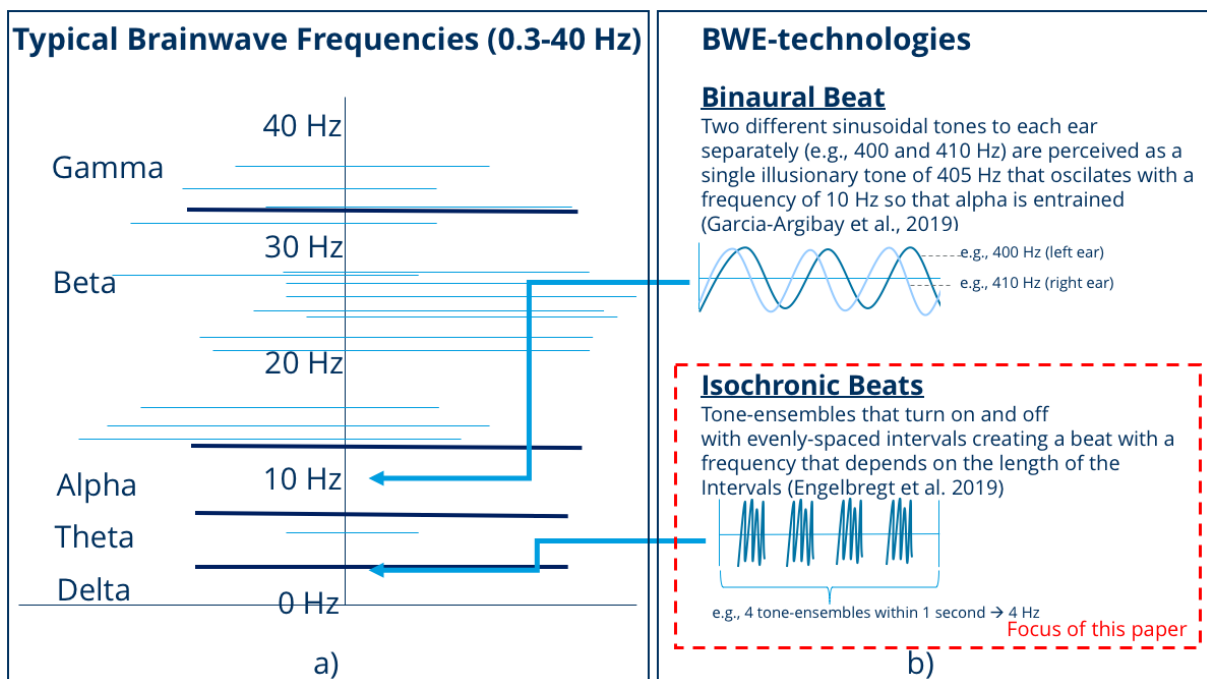


Figure 1. a) Typical Brainwave Frequencies and b) BWE-technologies that can be used to entrain Brainwave frequencies

Binaural beats exploit the effect that two different sinusoidal tones to each ear separately are perceived as a single illusory tone (Moore, 2012; Oster, 1973). For example, tones of 400 and 410Hz to each ear separately are perceived as a single tone of 405Hz and oscillates with a frequency of 10Hz (Garcia-Argibay et al., 2019) so that alpha waves are entrained (see Figure 1b). Garcia-Argibay et al., (2019) and Basu and Banerjee, (2020) have reviewed effectiveness of binaural beats and summarize that these beats are an effective way to reduce stress, anxiety and pain. Yet, the authors also comment that no effect has been found on inattention syndromes in children in (Kennel et al., 2010). In fact, BWE sound-providers such as (Daug, 2020a) assume that the illusory tone resulting from binaural beats is fragile and may be better perceived in a focused state (e.g., to deepen a meditative state).

Isochronic beats are reported to overcome this problem and are often described as being more effective than binaural beats (Berg and Siever, 2009; Obleser et al., 2017; Oster, 1973). Isochronic beats are tones

that turn on and off with evenly-spaced intervals, creating a beat with a frequency that depends on the length of the intervals (Engelbregt et al., 2019; see Figure 1b). These beats produce greater resonating response of brainwaves (Oster, 1973) and can be perceived without headphones (Berg and Siever, 2009). However, isochronic beats have rarely been scientifically investigated. As we aim to exploit the potential of BWE for stress relief and increase of concentration and wellbeing, we focus on isochronic beats, which do not necessarily require a certain focus (e.g., concentration level) to be effective and can be perceived without headphones so that this technology can easily be integrated in possible IS scenarios.

## 2.2 BWE and potential gender differences

BWE is a strategy to reduce stress and increase cognitive performance. While there are sex differences in stress responses (Hamidovic et al., 2020; Liu et al., 2017; Stroud et al., 2002) also sex differences in the auditory system have been predicted in the past (McFadden, 1998; Tobias, 1965). Yet, current results indicate that there are only little or no sex differences in cognitive abilities and some differences might be attributable to stereotypes (Hirnstein et al., 2014; Hyde, 2016; Waschl and Burns, 2020). However, a particularly interesting study for this subject is presented in (Norhazman et al., 2006). The authors investigated sex differences using traffic noise and binaural beat exposure. They report that on the one hand females are easier to be affected by (stress inducing) traffic noise than males. On the other hand, females can also be easier alleviated from stress using binaural beats in the range of alpha (Norhazman et al., 2006). Hence, although there is no evidence for sex-differences for cognitive abilities in general, this study points to differences of how BWE may be perceived by males and females. Accordingly, females tend to be easier alleviated from stress using binaural beats so that it is likely that BWE may in particular fit female needs. Hence, BWE may be a good starting point to configure products that are effective for females. This study first aims to investigate the potential of BWE to reduce stress and increase concentration and wellbeing for all potential BWE-users in general and for women in particular.

## 2.3 Hypotheses

While prior research has mainly investigated effectiveness of binaural beats for reducing stress and increasing concentration (Garcia-Argibay et al., 2019; Huang and Charyton, 2008), we focus on investigating isochronic beats in this paper, as this technique is reported to produce greater resonating response of brainwaves (Oster, 1973) and can be perceived without headphones (Berg and Siever, 2009). However, isochronic beats have rarely been investigated scientifically. Please note that in the following we refer to BWE to increase readability but still keep our focus on isochronic beats as a specific BWE-technology (see Figure 1b).

We first investigate for which problems BWE-users primarily utilize BWE. Knowing whether this technology is actually used to relief stress and boost concentration may clarify the potential of BWE in exceptional times. Furthermore, we investigate how users evaluate the extent to which BWE-utilization helps reducing stress and increasing concentration and wellbeing. For this evaluation, we include scales for wellbeing (WHO-5 Wellbeing Scale; Brähler et al., 2007) for stress (Depression, anxiety and stress scale; DASS; Nilges and Essau, 2015) as well as for concentration problems (Attention and Performance Self-Assessment, APSA; Bankstahl and Görtelmeyer, 2013). As effectiveness of binaural beats have already been investigated for concentration and stress (Garcia-Argibay et al., 2019; Huang and Charyton, 2008), we now investigate the effect on concentration and stress with a focus on isochronic beats with the following gender-independent hypotheses:

*H1: Participants report lower WHO-5 scores, indicating wellbeing, before treatment using BWE than afterwards.*

*H2: Participants report higher DASS scores, indicating experience of stress, before treatment using BWE than afterwards.*

*H3: Participants report lower APSA-scores, indicating the level of concentration, before treatment using BWE than afterwards.*

Note that we also hypothesized effects of BWE on depression, anxiety, addiction and sleep-related problems but we could not analyse those hypotheses. To keep the number of questions as low as possible, the questionnaires that were administered to the participants depended on the problem they stated as primary reason to use BWE (see 3.1. Research Design). For depression, anxiety, addiction and sleep-related problems the groups completing the respective questionnaires were too small (see Table 1) and therefore the statistical power would have been too low.

While we investigate the potential of BWE for reducing stress in general in hypotheses 1-3, we further aim to investigate the potential of BWE for female needs. As indicated in section 2.2, women are likely to profit from BWE to a larger extent as men, because women tend to be alleviated from stress more easily using binaural beats (Norhazman et al., 2006). This is why we further investigate the potential of BWE for reducing stress, increasing concentration and wellbeing for women as compared to men. Hypotheses pertaining to the difference between women and men are described below:

*H4: Increases in WHO-5 scores, indicating the increase of wellbeing using BWE, significantly differ between female and male subjects.*

*H5: Decreases in DASS scores for stress items, indicating the decrease of stress using BWE, significantly differ between female and male subjects.*

*H6: Decreases in APSA-scores, indicating the decrease of concentration problems using BWE, significantly differ between female and male subjects.*

### 3 Evaluation

For evaluating the above hypotheses, we conducted a survey including female and male BWE users of a German BWE-provider (Daug, 2020a) and collected data during September and October 2020. Daug gives detailed information in the supplementary material how users should apply the BWE-sounds so that users are guided when using BWE. For example, for the stress-related BWE-sounds the provider recommends a 15 or 30 minute-session that can be repeated on a daily basis. The survey design is described in the following section 3.1, the statistical analysis is described in section 3.2 and the results are discussed in section 3.3.

#### 3.1 Research Design

We asked subjects for what problems they primarily used BWE providing a selection of problems such as stress, concentration but also depression, anxiety, addiction and sleep disorders that sometimes result when being too stressed for a long-time (Marin et al., 2011; Plieger et al., 2015; Vinkers et al., 2014). Furthermore, subjects had the possibility to introduce own problems for which they use BWE or indicate other reasons that triggered BWE-usage. Based on their selected problem for using BWE we further included established questionnaires to retrospectively investigate their status before they started to apply BWE as a strategy to solve their problem and after they had finished to address this problem. In case they still use BWE for their problem, we asked the subjects to evaluate their current situation. For subjects who indicated that they use BWE to relief stress, anxiety or depression, we asked them to complete the Depression, Anxiety and Stress scale (DASS). This scale includes seven stress-items with questions such as “It was hard to wind down” and “I tended to over-react to situations” (for a complete list of questions pertaining to stress-item see Table 2 in the [online appendix](#)<sup>1</sup>). Subjects assessed each question by allocating scores ranging from 0 (did not apply to me at all) to 3 (applied to me very much). For those subjects that experienced concentration problems we asked to complete an Attention and

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<sup>1</sup> online appendix:

[https://www.dropbox.com/s/7g1rcp6f0jet7to/Online%20Appendix\\_BWE%20to%20support%20stress%20relief.pdf?dl=0](https://www.dropbox.com/s/7g1rcp6f0jet7to/Online%20Appendix_BWE%20to%20support%20stress%20relief.pdf?dl=0)

Performance Self-Assessment (APSA; Bankstahl and Görtelmeyer, 2013). This scale includes 21 items with statements such as “I could concentrate only for a very limited time span” (see Table 3 in the [online appendix](#)). Furthermore, we included self-report questionnaires for nicotine dependence (Fagerström Test for Cigarette Dependence; (Fagerström, 2011), alcohol dependency (Alcohol Use Disorder Test; Saunders et al., 1993), sleep disorder (PSQI; Buysse et al., 1989) as well as drug dependency (Inventory of Drug Taking; Watzl et al., 1991). Beyond the questionnaires that relate to the subjects’ individual problem, we further asked the subjects to complete a wellbeing questionnaire (WHO-5 Wellbeing Scale; Brähler et al., 2007). We included this questionnaire to measure the increase of wellbeing independently from their problem at hand, which allowed us to compare retrospective perception of wellbeing before and after treatment for a larger sample. The WHO-5 contains 5 questions (e.g., I have felt cheerful and in good spirits; I have felt calm and relaxed; for the full questionnaire see Table 1 in the [online appendix](#)). Subjects assessed each question by allocating scores ranging from five (all of the time) to zero (at no time). We focus in this report on wellbeing, stress, concentration, since these were the indicated psychological domains mostly addressed with BWE in our sample.

### 3.2 Statistical Analysis

To answer Hypotheses 1-3 we conducted three T-Tests for dependent samples with reported wellbeing scores (WHO-5 mean scores), stress scores (DASS-stress mean scores), and concentration scores (APSA-concentration mean scores) before and after treatment with BWE, respectively. To answer hypotheses 4-6 we conducted three separate 2x2 repeated measures ANOVAs with gender (male, female) as independent variable and time (before, after) as repeated measure variable with wellbeing, stress, and concentration scores as respective dependent variable. For all comparisons, the effect size  $\eta^2_p$  (partial Eta Square) is reported, whereas  $\eta^2_p \approx 0.01, 0.06, 0.14$  indicates a small-, medium-, and large-sized effect, respectively (Cohen, 1988).

### 3.3 Results

We first describe our results gender independently starting with the problems that subjects primarily addressed using BWE-technology. Afterwards, we report results of how BWE-users evaluate the effect of BWE for relief stress as well as increase wellbeing and concentration gender independently. Thereby, we address the relevance of BWE in general. Subsequently, we report the results distinguishing between male and female subject and hence, address hypotheses 4-6.

#### 3.3.1 Participants

We obtained 250 complete questionnaires using the online survey tool “SoSci Survey” (Leiner, 2014). Out of 250 subjects, who mainly used BWE on a daily to weekly basis over a period of several weeks to months, 80 subjects primarily used BWE to reduce stress, while 25 subjects primarily aimed at increasing concentration. The remaining subjects reported that BWE was primarily used to improve sleep (n=18), decrease anxiety (n=10), depression (n=5) and addiction (n=2). Furthermore, 35 subjects reported an individual problem that deviated from the problems given as selection and 75 subjects reported that BWE was rather used to investigate new possibilities than to address a certain problem. Since 32% of BWE-users that took part in the survey indicated that stress was the problem that they primarily addressed using BWE and 10% indicted that they primarily used this technology to increase concentration it is reasonable to assume that stress relief and increase in concentration are major problems that BWE-users address with this technology.

Distinguishing the subjects into males and females, we found that out of 250 subjects 125 subjects were female, 124 were male and 1 subject was diverse. Subjects had an average age of 54 years and reported that they had an average of 1,4 children. While distribution among female and male subjects was rather equal in this survey, the problems that male and female subjects addressed primarily with BWE differed. For example, 56% of female subjects used BWE primarily to address a specific problem as indicated in Table 1 (e.g., stress, concentration, sleep disorder etc.). In contrast, only 44% of the male subjects used BWE for specific problems. Instead, male rather than female subjects explored potential of BWE for



other scenarios such as deepening their meditation practice or increasing motivation. Among those problems specified in Table 1, female subjects also tended to address stress and concentration problems more often (58%) than male subjects did (42%).

| Problems       | Frequency (male and female) | Frequency (female) | Frequency (male)   | Frequency (diverse) |
|----------------|-----------------------------|--------------------|--------------------|---------------------|
| Stress         | 80                          | 47 (59%)           | 33 (41%)           | 0 (0%)              |
| Concentration  | 25                          | 14 (56%)           | 11 (44%)           | 0 (0%)              |
| Sleep disorder | 18                          | 10 (56%)           | 8 (44%)            | 0 (0%)              |
| Anxiety        | 10                          | 4 (40%)            | 6 (60%)            | 0 (0%)              |
| Depression     | 5                           | 2 (40%)            | 3(60%)             | 0 (0%)              |
| Addiction      | 2                           | 1 (50%)            | 1 (50%)            | 0 (0%)              |
| other Problems | 35                          | 14 (40%)           | 20 (57%)           | 1 (3%)              |
| no Problems    | 75                          | 33 (44%)           | 42 (56%)           | 0 (0%)              |
| <b>Total</b>   | <b>250</b>                  | <b>125 (50%)</b>   | <b>124 (49,6%)</b> | <b>1 (0,4%)</b>     |

Table 1. Problems that were primarily addressed using BWE-technology.

### 3.3.2 Hypotheses 1-3

Having introduced the problems subjects primarily addressed using BWE, we now report results of the gender independent hypotheses and hence address hypotheses 1-3. As indicated with the first rows in Table 2 we compared wellbeing over the whole sample.

| H  | Wellbeing  | N   | Mean  | SD    | SE    | t      | p     |
|----|--|-----|-------|-------|-------|--------|-------|
| H1 | Wellbeing before   | 248 | 2.258 | 1.093 | 0.069 | 17.388 | <.001 |
|    | Wellbeing after  | 248 | 3.376 | 1.026 | 0.065 |        |       |
|    | Wellbeing (stress-subjects) before   | 80  | 1.961 | 0.894 | 0.100 | 2.892  | <.001 |
|    | Wellbeing (stress-subjects) after  | 80  | 3.408 | 0.837 | 0.094 |        |       |
|    | Wellbeing (concentration-subjects) before  | 25  | 2.192 | 0.984 | 0.197 | 8.017  | <.001 |
|    | Wellbeing (concentration-subjects) after   | 25  | 3.352 | 0.876 | 0.175 |        |       |
| H2 | DASS (Depression-Anxiety-Stress Scale) for stress subjects using only stress items; before | 80  | 1.237 | 0.535 | 0.060 | 14.940 | <.001 |
|    | DASS (Depression-Anxiety-Stress Scale) for stress subjects using only stress items; after  | 80  | 0.487 | 0.434 | 0.049 |        |       |
| H3 | APSA (Attention and Performance Self-Assessment) for concentration subjects only; before   | 25  | 2.050 | 0.501 | 0.100 | 9.136  | <.001 |
|    | APSA (Attention and Performance Self-Assessment) for concentration subjects only; after    | 25  | 1.199 | 0.487 | 0.099 |        |       |

Table 2. Descriptives for the whole sample for wellbeing (WHO-5), stress (DASS), and concentration problems (APSA) as well as results from a paired sample T-Test.

We found that BWE helped subjects to significantly increase wellbeing from an average score of 2.258 to an average score of 3.376. Hence, we found support for hypotheses 1. As indicated above, we used wellbeing scores of all subjects independently for the reason they used BWE for. Accordingly, subjects that used BWE for meditation as well as those subjects that used BWE to decrease stress or increase concentration were included. As this paper focusses on stress relief and an increase in concentration, we also investigated whether an increase in wellbeing is also significant for those subjects that primarily used BWE to decrease stress and increase concentration. As can be seen in Table 2 a significant increase in well-being is experienced for subjects that use BWE-technology against stress (from an average of 1.961 to 3.408 WHO-5 scores) as well as against concentration problems (from an average of 2.192 to 3.352 WHO-5 scores). As expected, wellbeing before treatment was lowest for those subjects that primarily used BWE to ease stress (1.961 WHO-5 scores) while those subjects that used BWE to increase concentration reported a higher average before treatment (2.192 WHO-5 scores).

Furthermore, we investigated stress reduction as well as increase in concentration (hypotheses 2 and 3) using stress items of the ‘Depression, anxiety and stress scale’ (DASS; Nilges and Essau, 2015) for those subjects that used BWE to reduce stress. As can be seen in Table 2 means decreased from 1.237 before treatment to 0.487 after treatment and could hence be reduced significantly. For evaluating concentration before and after treatment, we used the Attention and Performance Self-Assessment (APSA; Bankstahl and Görtelmeyer, 2013) for those subjects that used BWE to increase concentration. As can be seen in Table 2 means decreased from 2.050 before treatment to 1.199 after treatment and could hence be reduced significantly.

### 3.3.3 Hypotheses 4-6

In the following, we report gender dependent results for the increase of wellbeing, decrease of stress as well as concentration problems (see Table 3). As can be seen in the first rows in Table 3, we found a trend to significance for differences between men and women in the increase of wellbeing. The average increase of WHO-5 scores were 1.000 for men and 1.228 for women. The effect is of small size. As can also be seen in Table 4, women generally started at a lower wellbeing level with an average of 2.170, while men started with an average of 2.356.

| H  | Wellbeing  | N   | Mean  | SD    | SE    | F     | p     | Effect size (Eta <sup>2</sup> ) |
|----|--|-----|-------|-------|-------|-------|-------|---------------------------------|
| H4 | Increase in wellbeing (women)                                      | 125 | 1.228 | 0.834 | 0.075 | 3.150 | 0.077 | 0.013                           |
|    | Increase in wellbeing (men)  | 122 | 1.000 | 1.162 | 0.105 |       |       |                                 |
| H5 | Decrease of stress-items in DASS (women)                           | 47  | 0.821 | 0.419 | 0.061 | 1.635 | 0.205 | 0.021                           |
|    | Decrease of stress-items in DASS (men)                             | 33  | 0.648 | 0.476 | 0.083 |       |       |                                 |
| H6 | Decrease of concentration problems measured in APSA scores (women) | 14  | 0.940 | 0.374 | 0.100 | 0.398 | 0.535 | 0.018                           |
|    | Decrease of concentration problems measured in APSA scores (men)   | 10  | 0.814 | 0.605 | 0.191 |       |       |                                 |

Table 3. Descriptives for the gender dependent increase of wellbeing (WHO-5), decrease of stress (DASS), and decrease of concentration problems (APSA) as well as results from the repeated measures ANOVA for the interaction effects gender x time (before, after) for wellbeing, stress, and concentration.



For stress, the average score before treatment for men and women was relatively equal around 1.2 DASS-scores (see Table 4). Yet, average decreases of DASS-scores for stress-items tend to be higher for women (0.821) than for men (0.648) although no significant gender x time (before, after) effect could be found (see Table 3). In contrast to wellbeing, men reported a lower average APSA-score indicating concentration problems before treatment than women. As can be seen in Table 4, the average APSA-scores of men before treatment was 2.121 while the average APSA-scores for women was 1.995. As for wellbeing and stress, women reported a higher but not significant decrease of APSA score (0.940) than men (0.814).

|  | Women |       |       | Men |       |       |
|--|-------|-------|-------|-----|-------|-------|
|  | N     | Mean  | SD    | N   | Mean  | SD    |
| Wellbeing before (WHO-5 Scale)   | 125   | 2.170 | 1.067 | 122 | 2.356 | 1.115 |
| Wellbeing after (WHO-5 Scale)  | 125   | 3.398 | 0.949 | 122 | 3.356 | 1.106 |
| DASS (Depression-Anxiety-Stress Scale) for stress subjects using only stress items; before | 47    | 1.254 | 0.495 | 33  | 1.211 | 0.594 |
| DASS (Depression-Anxiety-Stress Scale) for stress subjects using only stress items; after  | 47    | 0.434 | 0.364 | 33  | 0.563 | 0.514 |
| APSA (Attention and Performance Self-Assessment) for concentration subjects only; before   | 14    | 1.995 | 0.559 | 10  | 2.121 | 0.434 |
| APSA (Attention and Performance Self-Assessment) for concentration subjects only; after    | 14    | 1.055 | 0.357 | 10  | 1.400 | 0.586 |

Table 4. Descriptives for the gender dependent wellbeing scores (WHO-5), stress scores (DASS) and scores indicating concentration problems (APSA).

## 4 Discussion

This survey shows that BWE reveals a high potential to increase wellbeing and concentration as well as decrease stress. Furthermore, we detected that BWE is used for different reasons by men and women and seems to have a different effect on the wellbeing of men and women. We found a trend to significance for differences between men and women in the increase of wellbeing and differences in means for stress reduction and increase in concentrations although no significant effect could be found. These results indicate that BWE-technology offers a potential for women to provide instant help to relief stress as well as increase concentration and wellbeing. We consider this potential at least similar to BWE for men and want to recommend to investigate possible differences between men and women in the use and the effects of BWE in further studies. These results are in so far promising as BWE only requires little or no time investment. To increase concentration, BWE can be used while working so that no extra time is required. To increase relaxation, BWE can be used for short times such as a 15 to 30 minute breaks e.g., while walking home or while using public transport. In this regard, applying BWE for relaxation can also be done without an extra time investment while an online yoga or meditation-session typically requires to set apart some extra time. Using such a tool may provide women and men with the instant help they require in crisis times to be able to care for their family as well as to meet their work duties. In the following, we aim to describe the potential of BWE for traditional IS areas as well as emerging IS areas such as digital wellbeing and positive computing.

## 4.1 Potential IS-BWE research

Traditionally, improvements in efficiency and effectiveness are key outcomes in many IS and design-oriented research areas (Pawlowski et al., 2015). A broader perspective on outcomes including wellbeing and quality of life is taken in positive computing (Pawlowski et al., 2015). Positive computing is rooted in positive psychology, which emphasizes people's potential instead of their deficit and explores conditions that promote their wellbeing and flourishing (Seligman and Csikszentmihalyi, 2014). Possible applications of positive computing are multifaceted comprising applications for traditional IS areas such as telework, education and health care (section 4.1.3-4.1.2) but also for emerging IS areas such as digital wellbeing and Neuro-IS (section 4.1.4-4.1.5).

### 4.1.1 BWE as telework-enabler

During the Covid-19 crisis teleworking has been used by companies to ensure their employees' safety and to provide continuity to economic activity (Belzunegui-Eraso and Erro-Garcés, 2020). However, this crisis has shifted millions of people from working at their workplace to teleworking from home and thereby generated a hybrid space of work which is nowadays called home office (Katsabian, 2020). For working in home office, several advantages have been reported such as more flexibility to respond to family demands (Golden and Fromen, 2011) and reduced work exhaustion (Golden, 2006). Yet in times of Covid-19 these advantages are likely to turn into disadvantages for parents, who need to homeschool their kids and secure childcare for the younger children often simultaneously while working. Being flexible to respond to family demands is now likely to lead to too many home-to-work transitions as required interruptions of work activities to deal with home demands during work hours (Delanoëje et al., 2019). These transitions are likely to impact the parents' concentration and hence impact on the quality of work itself.

Results of this survey indicate that BWE reveals potential to increase concentration with no additional time investment since it is usually recommended to use BWE while doing the usual working (Daug, 2020a). Accordingly, teleworkers may use headphones to listen isochronic beats while working, which also help shielding the working parent from distractions (e.g., noises from children that are supervised by the other parent).

### 4.1.2 BWE to boost concentration and relief stress for e-Learning

During the COVID-19 crisis, e-Learning has become a mandatory component of all educational institutions including schools, colleges and universities (Radha et al., 2020). Faculty members of renowned universities deliver online teaching to their students (Sahu, 2020). While e-Learning allowed to continue academic education, it is also perceived as stressor for students. Hasan and Bao, (2020) report that online class registration, tiny performance appraisal systems, one-way instructor support as well as e-Learning content costs are relevant psychological stressors. They also report that in particular content that was hard to understand during an eLecture and non-transparent enrolment procedures were associated with fear of academic loss. BWE may be used to relief stress and boost concentration when being integrated in e-Learning systems. For example, general instruction pages may be accompanied with isochronic beats that entrain alpha brainwaves so that students find it pleasant to spend time for organizing their learning material and planning their curriculum. Furthermore, specific learning environments that aim to convey knowledge may exploit the potential to increase concentration by entraining beta brain-waves to support information intake.

BWE-providers have already pinpointed to the potential of BWE for learning material such as vocabularies. For example, (Daug, 2020b) gives detailed instruction how to use BWE to enhance learning of vocabulary. This practitioner recommends to first entrain alpha waves to become relaxed and open for learning new material. After a period of 10 minutes, students are encouraged for information intake while entraining beta-waves to boost concentration for this study period. To further facilitate information integration of what has just been learned, Daug (2020b) further recommends a period in which students should alternate between a) laying back and listening to the BWE-sounds and b) calmly reviewing the material that has just been learned while still listening to the alpha sounds in

the background. Universities as well as other e-Learning providers may profit from exploiting the potential of stress relief before learning, boosting concentration during learning sessions and facilitating mental integration of what has just been learned.

#### **4.1.3 BWE as an adjuvant treatment option by integrating BWE into clinical information systems as well as patient pathways**

BWE also has the potential to be used as an supportive treatment option that health professionals working with patients suffering from mental illnesses can integrate into their treatment strategy to ease stress symptoms. BWE may best be exploited as integrated technology into clinical information systems and into well-defined treatment processes, also known as patient pathways. Such a pathway guides through the whole journey a patient takes by defining goals and milestones, and supports mutual decision-making of patient and corresponding health care professional with a strong focus on patient empowerment and engagement as well as care continuity in a network of different care providers (Richter and Schlieter, 2019). With such an integration it is possible to render BWE accessible whenever clinicians and patients see an opportunity for it. For example, BWE may be used to bridge future patients' waiting periods before individual, guideline-based treatment as well as to further relieve patients from stress (e.g., at home) and stabilize these patients. Furthermore, therapy phases that temporarily but inevitably increase stress in patients may additionally be accompanied with BWE-treatment to reduce stress after such sessions. Finally, such a BWE integration allows for several use cases. For example, different stakeholders such as health professionals may to customize the usage of BWE for specific purposes and to keep track of their patients' BWE-usage. Furthermore, patients may directly access a BWE-system for treatment, track their use of BWE to be empowered and share this usage information with their health care provider.

#### **4.1.4 BWE-technology to promote digital wellbeing**

While positive computing can add a new perspective of IS outcomes such as wellbeing and quality of life for many traditional IS areas, it also directly impacts on digital wellbeing, which is now discussed as an emerging IS-area (Vanden Abeele, 2020). Digital wellbeing refers to the individual experience of balance and drawbacks through mobile connectivity (Vanden Abeele, 2020). On the one hand, mobile connectivity increases autonomy by enabling people to flexibly respond to information so that when a train is delayed, people can catch up their work using their laptops or inform their partners (Abeele et al., 2018; Castells et al., 2009; Vanden Abeele, 2020). On the other hand, mobile technology can also challenge autonomy by directing attention away from people's primary activity such as work (Williams, 2018) or by imposing the pressure to check, act and respond to information (Abeele et al., 2018; Vorderer et al., 2016). To counterbalance drawbacks through mobile connectivity many digital wellbeing apps have emerged that aim to promote a more conscious use of IT. Such wellbeing apps comprise features for self-monitoring (e.g., phone unlocks, app checking) as well as for interventions (teak a break-interventions, notification blockers, rewards; Monge Roffarello and De Russis, 2019).

BWE also offers potential to either increase autonomy or help coping with challenges that technology may impose on its users. Based on the frequency chosen, BWE allows for stimulating different functions of the brain, which are associated with focus and alertness (beta waves), relaxation (alpha waves) or creative thinking (theta waves; Ashtaputre-Sisode, 2016; Puzi et al., 2013). Stimulating beta, may foster one's concentration and focus and hence help to keep focussing on work as a primary activity without the constant need and desire to shift attention away. Stimulating alpha may help to better relax and cope with technostress (Weinert et al., 2020) as well as help to resist to unintendedly act and respond to information when one actually aims to engage in social and leisure activities (Vanden Abeele, 2020). Being focussed and relaxed may then help to deal with a lot of different stressors such as pressure in work environments (Krell et al., 2009) as well as to concentrate on one's goals (Matook, 2013) while still fostering interpersonal relationships (Madsen and Matook, 2010) and self-organization (Matook et al., 2016). Accordingly, BWE promotes positive computing outcomes such as wellbeing and relaxation while also allowing for more autonomy by e.g., stimulating the function of the brain that best fits the chosen task and hence, also helps to increase digital wellbeing.

#### 4.1.5 Potential for Neuro-IS-research

While, so far, we have discussed BWE as a direct intervention (e.g., for telework, e-Learning, health care and digital wellbeing), BWE may also be exploited as a neurophysiological tool that facilitates research in the area of Neuro-IS. Neuro-IS investigates the use of neurophysiological tools in IS research (Dimoka et al., 2012). BWE-technology is a neurophysiological tool that aims to entrain brainwave frequencies of a certain spectrum and by that influences the subjects' mental state (e.g., stressed - high beta, concentrated - beta, relaxed - alpha). Inducing a certain mental state in subjects may allow to design experiments that were otherwise difficult to enable. For example, BWE-technology can help to induce stress on subjects, which may be useful to investigate how stressed customers react in online environments.

#### 4.2 Limitations

For this study, data indicating the level of stress, concentration as well as wellbeing is collected in retrospection. Accordingly, BWE-users answered questions pertaining to their situation before they started to employ BWE for the problem and after they have finished to address this problem with BWE at the same time. Another problem is that users who do not perceive any effects may have not continued using BWE, which can lead to a bias in the sample. Although the potential of BWE to ease stress, and increase wellbeing and concentration has been shown, further prospective research is needed to investigate the extend of the effect that BWE has on stress, wellbeing and concentration. While we have shown that BWE-users perceive long-term effects for stress-relief as well as increase in wellbeing and concentration, we have not focused on instant effects that are also required in such exceptional times. For investigating instant effects, we plan to conduct an electroencephalography (EEG)-study to assess whether frequencies used by the BWE entrains a corresponding brainwave frequency that can be measured using EEG.

### 5 Conclusion

In this study we have addressed the potential of BWE for crisis situations in which additional time investment to relief stress and increase wellbeing and concentration is restricted. Using a survey, we found that BWE-users already utilize this technology to increase concentration and reduce stress and perceive a significant effect on increasing wellbeing and concentration as well as decreasing stress through the use of BWE. We also found a trend to significance for differences between men and women in the increase of wellbeing and differences in means for stress reduction and increase in concentrations although no significant gender x time (before, after) effect could be found. Based on these results, it may be reasonable to assume that BWE offers a high potential to help women coping with difficult situations such as the COVID-19 crisis. Yet, further prospective research is needed to specify the difference between man and women. Addressing its general potential of IS-research, we have further discussed a wide variety of traditional and emerging information systems research areas that may profit from integrating BWE-technology such as e-Learning, eHealth, telework as well as digital wellbeing and with that pointed to the potential of BWE as a means to support Human Computer Interaction.

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