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Do Workplace Fish Tanks Influence Employee Wellbeing and Cognitive Performance? An Embedded Mixed-Methods Study

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ABSTRACT

Evidence from "pet-friendly" workplaces highlights potential benefits associated with taking companion animals to work, including reduced stress among employees. Ornamental fishes carry a much lower risk than other companion animals and may be a suitable alternative in situations where other animals would introduce too great a risk (e.g., allergy, accidental injury). The aim of this study was to investigate whether watching an aquarium during the working day influenced employee wellbeing through the reduction of stress and improvements in stress-related outcomes. An embedded mixed-methods study was conducted, comprising two within-subjects trials (Trials A and B) and a qualitative follow-up. Participants were university employees and research students who participated during their working day. In Trial A ($n = 30$), the immediate effects of watching live fishes on mood, physiological stress, and cognitive performance were compared with the effects of watching a fish video or resting quietly. Although some outcomes improved from pre- to post-activity, there was no evidence that watching fishes (live or video) had greater effects than resting quietly. In Trial B ($n = 27$), the effects of repeatedly engaging in the same three activities over several weeks were examined. Watching fish videos was associated with improvements in "high pleasure-low arousal" and overall job-related affective wellbeing, but no further effects of condition were found. Qualitative follow-up data collected from a subset of participants from the experimental trials ($n = 13$) indicated that all three activities may be beneficial as leaving their desks provided detachment from work for a short period. Qualitative data suggested that live fishes were perceived as more engaging, but this did not translate to quantitative findings. Locating fish aquaria within offices (rather than a separate workplace location) may promote wellbeing by encouraging "microbreaks"; further research is needed to investigate this hypothesis.

KEYWORDS
Employee wellbeing; human–animal interaction; ornamental fishes; work-related stress

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Work-related stress is a widespread problem which affected around 828,000 people in the UK during 2019–2020 (Health and Safety Executive, 2020), with significant economic implications (Hassard et al., 2018). Afflicted individuals may experience physical or psychological ill-health, with prolonged cases potentially leading to “burnout” and impacting the individual’s concentration and performance (Colligan & Higgins, 2006; Johnson et al., 2005; Maslach et al., 2001; van der Klink et al., 2001; Van Der Linden et al., 2005). Research within “pet-friendly” workplaces suggests that the presence of animals may positively influence wellbeing (Hall et al., 2017; Wells & Perrine, 2001). One study conducted within a dog-friendly workplace found that employees who brought their dogs to work reported lower perceived stress than those without companion animals, although no differences were observed in levels of salivary cortisol (Barker et al., 2012). As there is robust evidence to demonstrate an association between both acute and chronic stressors and negative health outcomes (Glaser & Kiecolt-Glaser, 2005; Krantz & McCeney, 2002; O’Connor et al., 2021), as well as links between stress and poorer mental health (Harvey et al., 2017; Kalisch et al., 2017), this may have important implications for employee health and wellbeing.

Stress negatively impacts cognitive functions, such as memory or attention (Sandi, 2013). Although no studies have examined the effect of human–animal interaction (HAI) on cognition within the workplace, the presence of a person or therapy dog during the completion of a working memory task improved performance among university students, suggesting animal presence may positively influence cognition (Gee et al., 2015). However, physically touching the dog during the completion of the task led to the poorest performance, perhaps because the requirement to maintain contact interfered with the completion of the task (Gee et al., 2015). Supporting this, evidence shows that task difficulty interacts with dog guardianship status to influence HAI effects; anxiety is reduced among dog guardians who completed a moderately difficult task in the presence of a dog, but it increased during a task of extreme difficulty (Stewart & Strickland, 2013). This perhaps occurred because participants wanted to interact with the animal but could not due to task demands (Stewart & Strickland, 2013).

Research exploring HAI in the workplace has focused almost exclusively on “pet-friendly” workplaces (for a review, see Foreman et al., 2017); however, “pet-friendly” approaches are unlikely to be suitable across all working environments as animals may introduce risk into the workplace. One less intrusive alternative may be the installation of fish aquaria. To our knowledge, only one study has examined the influence of aquaria on employee wellbeing; Lin et al. (2013) surveyed hospital medical directors in Taiwan and found that the presence of aquaria did not moderate the effects of patient-related stress (i.e., physician–patient relationship stress and patient-condition stress) on self-reported health. However, research in other settings has suggested that interacting with fishes in aquaria may alleviate stress or anxiety and reduce physiological arousal (Buttelmann & Römpke, 2014; Gee et al., 2019). Watching videos of animals, including fishes, is associated with reduced physiological arousal (Wells, 2005).

One potential explanation for the apparent stress-reducing effects of watching fishes is that companion animals promote wellbeing by capturing attention and diverting it away from negative stimuli, such as the experience of stress or negative emotional states (Beetz, 2017). In support of this theory, there is evidence that humans preferentially attend to animals over non-living objects (DeLoache et al., 2011; Lobue et al., 2013; New et al., 2007). Fishes may be particularly effective at capturing attention; higher levels of stocking and biodiversity were associated with longer viewing times at a public aquarium (Cracknell et al., 2016), and the presence of aquaria in shop windows was associated with increased attention from passers-by (Windhager et al., 2011).

Alternative explanations come from research on the restorative value of nature, where greater access to nature, including indoor nature, has been associated with lower levels of perceived stress and stress-related health complaints (Largo-Wight et al., 2011; Thompson & Bruk-Lee, 2019). Two complementary theories may explain these findings. Stress Recovery Theory (SRT) (Ulrich, 1983; Ulrich et al., 1991) states that someone experiencing psychophysiological stress will experience positive emotions in response to unthreatening nature, leading to reduced physiological arousal (Ulrich, 1983, 1993). As stress is associated with declines in cognition function, gains in cognitive performance may also be observed (Ulrich et al., 1991). Attention Restoration Theory (ART) (Kaplan, 1995) focuses on the concept of directed attention, the mechanism required to focus and inhibit outside distractions. ART argues that this mechanism becomes fatigued with use but can be restored by exposure to "fascinating" components of nature that attract attention effortlessly (Basu et al., 2019; Kaplan & Berman, 2010). While both theories suggest that exposure to nature may lead to restoration, SRT focuses on reductions in physiological arousal and improvements in affect, whereas ART focuses on the rapid recovery of directed-attention resources. As fish tanks bring nature indoors (Largo-Wight et al., 2011), these theories support the notion that aquaria in the workplace may promote employee wellbeing by helping to reduce psychophysiological stress and supporting cognitive function.

Therefore, this research aimed to examine whether watching an aquarium containing ornamental fishes during the working day influences employee wellbeing through the reduction of stress and improvements in stress-related outcomes. Based on theories of restoration (SRT and ART), it was hypothesized that watching ornamental fishes would lead to greater reductions in psychophysiological stress and improvements in cognitive performance than resting quietly; this would be evidenced by greater improvements in mood (positive and negative affect), greater reductions in perceived arousal and physiological indicators of stress (heart rate, blood pressure, salivary cortisol), and greater improvements in performance on tasks of direct attention (inhibitory control, working memory) immediately after viewing the fishes. It was further hypothesized that repeated viewings of the fishes over several weeks would lead to greater improvements in stress-related outcomes, both psychological (depression, anxiety, stress, job-related affective wellbeing) and physiological (heart rate, blood pressure). Finally, it was hypothesized that watching live fishes would lead to more positive effects than watching fish videos.

Methods

Design

An embedded mixed-methods design (Cresswell, 2014) was used (see Figure 1a). Quantitative data were collected through two concurrent experimental trials (Trials A and B), with qualitative data collected via follow-up focus groups.

Trial A assessed the immediate effects of watching fishes and utilized a two-way, within-subjects design (Figure 1b). The independent variables were experimental condition ("aquarium," "video," "control") and time ("pre-test," "post-test"). Dependent variables were selected to detect fluctuations over short time periods (i.e., minutes rather than days or weeks), and included mood (positive affect, negative affect, perceived arousal), physiological stress (heart rate, blood pressure, levels of salivary cortisol), and cognitive performance (inhibitory control, working memory).

Trial B utilized a one-way, within-subjects design (Figure 1c) and examined longer-term changes in wellbeing; the independent variable was condition ("aquarium," "video," "control") and the dependent variables were psychological (depression, anxiety, stress, job-related affective wellbeing) and physiological (heart rate and blood pressure) wellbeing. It was also recognized that attitudes toward one's job may influence psychological wellbeing at work, and so job satisfaction was measured at baseline in Trial B. Details of the outcome measures are given in Table 1.

Experimental Conditions

There were three experimental conditions in the trials: "aquarium," "video," and "control." The aquarium consisted of a 54-litre fish tank stocked with zebrafish (*Danio rerio*), variatus platys (*Xiphophorus variatus*), and cory catfish (*Corydoras paleatus*, albino *C. aeneus*). Owing to occasional fish mortality, the tank contained 5–6 zebrafish, 4–6 platys, and 2–5 cory catfish. Water changes, water testing, and tank maintenance were conducted weekly, and feeding occurred twice daily via an automatic feeder. Water quality (API 5-in-1 and ammonia test strips) remained high throughout the experimental period. The video showed an identical tank displayed on a 24-inch (~61 cm) television; during

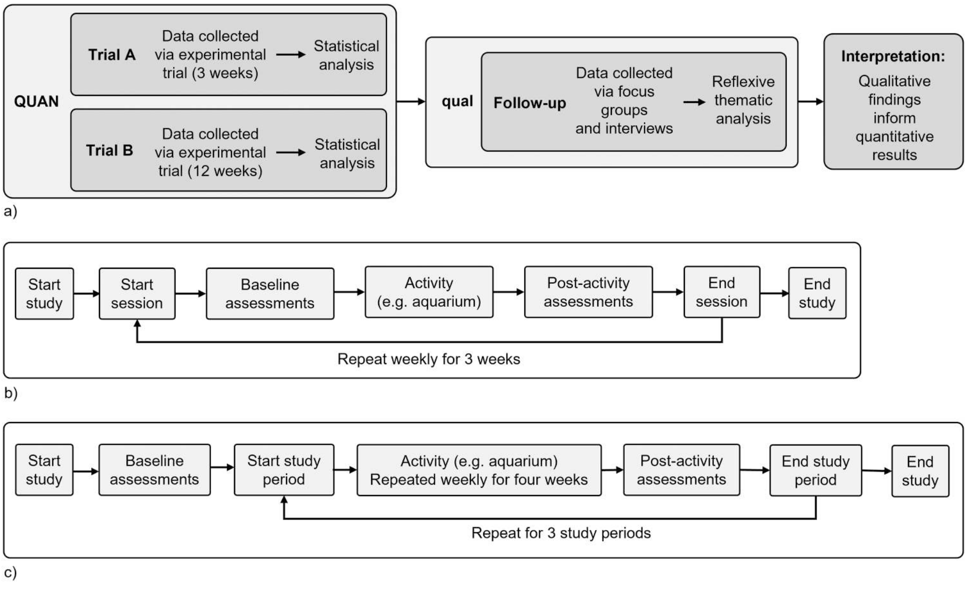

Figure 1. Overview of study design: (a) embedded mixed methods design, (b) design of Trial A, (c) design of Trial B.

Table 1. Outcomes assessed in Trial A and Trial B.

	Outcome	Assessment method
Trial A	Mood: positive and negative affect, perceived arousal	Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), consisting of 20 items (10 per scale) relating to positive and negative affect (e.g., "interested" or "ashamed"). Perceived Arousal Scale (PAS; Anderson et al., 1995) consisting of 24 items relating to low and high arousal (e.g., "drowsy" or "active"). Responses given on a scale of 1 ("very slightly or not at all") to 5 ("extremely"). Negatively worded items were reverse scored (PAS only), and responses summed for total scores; higher scores indicate higher levels for each state (Cronbach's $\alpha = 0.77–0.92$).
	Physiological stress: heart rate, blood pressure, salivary cortisol	Heart rate measured using a Polar® H7 heart rate sensor to obtain real-time heart rate measurements via smartphone application (Polar Beat, Polar Electro®). Systolic and diastolic blood pressure measured using an automatic blood pressure monitor (Omron M3, Model HEM-7131-E), using the same arm for each measurement with each participant. Salivary cortisol analyzed using commercial ELISA kits (Enzo Life Sciences, Cortisol ELISA kits, ADI-900-071 and ADI-901-071) following the manufacturer protocol. Samples were collected via the passive drool technique, immediately placed on ice, and stored at −80°C. Directly before analysis they were defrosted and centrifuged (2 min, 4°C, 14000 rpm); steroid displacement reagent was added as per manufacturer instructions and samples were diluted at a ratio of at least 1:1 standard diluent to sample. To account for inter-plate variability, all samples for each participant were analyzed on the same plate, excepting one that was re-run due to readings indicative of contamination. All outcomes were measured once at rest, with the participant in a seated position.
	Cognitive performance: inhibitory control and working memory	Inhibitory control measured using the Stroop Color-Word Task (SCWT; Stroop, 1935). Participants were required to state the color of 100 color words printed in the wrong color (e.g., the word "brown" in red ink), thus requiring overriding of the automated response (reading the word) with a less automated response (saying the color). Number of errors (SWCT-Errors) and time taken in seconds (SCWT-Time) were recorded. Working memory assessed using the digit-span forwards (DSF) and backwards (DSB). Participants heard a list of digits (e.g., "8, 9, 3") and repeated them back either in the same direction (DSF) or reversed (DSB). If successful, the length of the list was increased by one (max = 9 digits) until recall failed on two subsequent trials. Scores for each were the length of the longest list correctly recalled. Both tasks have been used to assess attentional capacity in past research (Ohly et al., 2016).
Trial B	Psychological wellbeing: depression, anxiety, stress, job-related affective wellbeing	The Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995), consisting of three 14-item scales. Participants indicated how much each statement (e.g., "I found myself getting upset by quite trivial things") had applied to them over the past week, from 0 ("Did not apply to me at all") to 3 ("Applied to me very much, or most of the time"). The short Job-related Affective Wellbeing Scale (JAWS; Van Katwyk et al., 2000), consisting of 20 job-related emotion

(*Continued*)

Table 1. Continued.

Outcome	Assessment method
	statements (e.g., "My job made me feel angry"). Participants indicated how much they had experienced each emotion over the past 30 days, from 1 ("never") to 5 ("extremely often"). The high pleasure-high arousal (e.g., "enthusiastic"), high pleasure-low arousal (e.g., "calm"), low pleasure-high arousal (e.g., "angry"), low pleasure-low arousal (e.g., "depressed") subscales were also calculated.
	For each questionnaire, negatively worded items were reverse scored (JAWS only) and responses summed for a total score so that higher scores indicated greater experience of that state (Cronbach's $\alpha = 0.74–0.94$).
Physiological wellbeing: heart rate, blood pressure	Heart rate and blood pressure were measured as in Trial A. Salivary cortisol is highly influenced by extraneous variables, so was not assessed in Trial B.
Job satisfaction (covariate)	The Job Satisfaction Survey (JSS; Spector, 1985). Participants indicated how much they agreed with 36 statements (e.g., "I feel I am being paid a fair amount for the work I do") on a 6-point scale, from 1 ("disagree very much") to 6 ("agree very much"). Negatively worded items were reverse scored and all responses were summed for a total score, with higher scores indicating higher levels of job satisfaction (Cronbach's $\alpha = 0.88$). Subscales of the JSS were not calculated.

Note: Effects of watching fishes on cognitive performance were expected to be transient, so cognitive outcomes were not assessed in Trial B.

applicable sessions, the television was placed directly in front of the covered tank. No experimental stimuli were used in the control condition, with participants simply asked to sit quietly and relax.

The research was conducted at two of five campuses from the same university, with all conditions taking place in a private office or laboratory (depending on the campus) away from participants' usual offices. Trials were conducted under laboratory conditions, with the sound of running water produced by the aquarium filter present in all conditions, so that any effects were attributable to watching the fishes rather than other factors associated with aquarium presence (e.g., being involved in fish care).

Participants and Procedure

Ethical approval was obtained from the School of Health and Life Sciences ethics committee at the University of the West of Scotland (Ref: 4940) and the Mars Research Review Board.

University employees and research students were opportunistically recruited via written and electronic communications and randomly assigned to either Trial A ($n = 30$) or B ($n = 27$) after consenting to take part. This population was selected for convenience and because it included professions associated with higher-than-average work-related stress (e.g., teaching, research, and administrative professionals; Health and Safety Executive, 2020). All staff members and research students were eligible to participate. Sample sizes exceeded those required to detect a medium-sized effect with 80% power, as determined by *a priori* power analyses (Faul et al., 2007). All participants received vouchers for hot drinks for taking part; sample characteristics are summarized in Table 2.

Table 2. Participant characteristics for original and follow-up samples.

	Original sample ($n = 57$)			
	Trial A ($n = 30$)	Trial B ($n = 27$)	Total ($n = 57$)	Follow-up ($n = 13$)
Campus				
1	22 (73%)	21 (78%)	43 (75%)	10 (77%)
2	8 (27%)	6 (22%)	14 (25%)	3 (23%)
Job role				
Academic	9 (30%)	8 (30%)	17 (30%)	6 (46%)
Research student	8 (27%)	7 (26%)	15 (26%)	3 (23%)
Other	13 (43%)	12 (44%)	25 (44%)	4 (31%)
Gender				
Male	8 (27%)	8 (30%)	16 (28%)	4 (31%)
Female	22 (73%)	19 (70%)	41 (72%)	9 (69%)
Age in years	39.73 ± 11.05	41.41 ± 11.88	40.53 ± 11.38	40.54 ± 11.29
Fish guardianship				
Any time	21 (70%)	20 (74%)	41 (72%)	10 (77%)
Childhood	15 (50%)	15 (56%)	30 (53%)	4 (31%)
Adult – not current	5 (17%)	7 (26%)	12 (21%)	3 (23%)
Adult – current	4 (13%)	4 (15%)	8 (14%)	3 (23%)
Dropout	0	5 (19%)	–	–

Note: Data for categorical variables are frequencies and percentages; data for continuous variables are means and standard deviations. Participants could provide multiple responses to questions regarding fish guardianship.

In Trial A, participants completed three 30–40-min sessions over three consecutive weeks; wherever possible, sessions were at the same time and on the same day each week. Written informed consent was obtained at the start of the first session, after which participants completed the demographic questionnaire. Each session then followed the same procedure. Pre-test assessments were conducted in the following order: psychological (affect and arousal), physiological (heart rate, blood pressure, saliva sample), and cognitive (digit span tasks, Stroop Color-Word Test (SCWT)). This order was used as measuring physiological outcomes could influence psychological outcomes, and completing cognitive tasks could affect both psychological and physiological outcomes. Immediately following pre-test assessments, participants engaged in one experimental activity ("aquarium," "video," "control") for 10 min, with order of exposure counterbalanced across participants and randomly assigned using a random number generator. A 10-min intervention period was selected based on previous research (Cracknell et al., 2016) and because a longer period was not realistic within a working environment. Heart rate was noted halfway through the intervention period, and post-test assessments were made immediately following completion of the activity, in the same order as at baseline. Data were collected from October 2018 to February 2020.

Participants completed Trial B over a 12-week period, consisting of weekly sessions divided into three 4-week study periods, each involving repeated engagement in one of the three treatment conditions ("aquarium," "video," "control"). The order of exposure was again counterbalanced. Written informed consent was collected at the start of the first session, after which participants completed the demographic questionnaire, the Job Satisfaction Survey, and baseline psychological assessments. Each study period then followed the same procedure. Weeks 1–3 involved only the experimental activity; participants were seated comfortably and engaged in one activity for 10 min. In the final week of each study period, heart rate and blood pressure were measured immediately before and after participants engaged in the activity, with heart rate also noted midway through the intervention period. Following the "after" physiological assessments, psychological outcomes were reassessed. Data were collected between January 2019 and March 2020.

Following preliminary analysis of the quantitative data, qualitative follow-up data were collected to provide a deeper understanding of the findings. A subset of participants was recruited via the same procedure as above, with representation from Trials A ($n = 5$) and B ($n = 8$). Data were collected during April and May 2020 via semi-structured focus groups; questions focused on participants' experiences and how these differed (if at all) across the three conditions. Written informed consent and demographic details were obtained via e-mail prior to the focus group, with all data collected via video conferencing. Four focus groups were conducted, lasting 16–34 min and containing 2–5 participants. In addition, one individual interview (~ 12 min) was conducted based on the participant's preference. With participant permission, data were audio recorded using a Sony ICD-PX470 digital dictation machine and transcribed verbatim for analysis.

Data Analysis

Quantitative Data

All participants completed Trial A. Self-report measures were checked for completeness prior to data entry; in four instances, a response was missing to one item on the scale and so was imputed using the mean of completed responses. Five participants dropped out of Trial B and an additional 13 missed at least one session. If any participant attended fewer than two sessions during a study period, their data for that period were excluded from analyses. With instances of pre-arranged leave, some assessments were made one week early to avoid missing data. Mean imputation was applied to replace missing values on self-report measures for seven participants. In two further instances, many responses were missing and so imputation was not appropriate; thus, these data were excluded from the analysis. Following imputation, complete psychological data were available for all participants in Trial A and 18 participants in Trial B. Complete cortisol data were available for 25 participants, and all participants provided data on cognitive performance (both measured in Trial A only); complete data on blood pressure were available for all participants in Trial A and 17 in Trial B. Due to equipment failure, heart rate data were missing for a substantial number of participants in both trials and so are not reported.

All data were analyzed using *R* version 4.0.0 (R Core Team, 2020). The assumption of normality was violated in all cases, so data were analyzed using robust methods that provide more reliable estimates in the face of violations (Field & Wilcox, 2017). For Trial A, separate robust within-by-within (condition-by-time) procedures were conducted via the package *WRS* (Wilcox & Schönbrodt, 2014) for each dependent variable. All analyses utilized 20% trimmed means and bootstrapped samples ($n = 2{,}000$). Where significant main effects were detected, these differences were investigated through inspection of trimmed means and robust pairwise comparisons with Rom's corrected alpha levels.

Due to the presence of missing data for outcomes in Trial B, these data were analyzed using linear mixed models for maximum data retention; as model assumptions were violated, robust models were conducted via the package *robustlmm* (Koller, 2016). A participant was entered as a random factor and the condition was entered as a categorical predictor with three levels (aquarium, video, and control). For the psychological outcomes, baseline scores and job satisfaction were entered as continuous predictors. For blood pressure, time was entered as an additional categorical predictor with two levels (baseline and post-activity). As this package does not provide *p*-values, 95% Wald confidence intervals were calculated, and predictors were considered statistically significant if the confidence interval did not cross zero. Where significant effects of condition were detected, sensitivity analyses were conducted to assess the robustness of the effect; this involved repeating the analysis for the subset of participants with complete data.

Qualitative Follow-Up Data

Data were managed in NVivo 12 Pro and analyzed using reflexive thematic analysis (Braun et al., 2019; Braun & Clarke, 2006, 2019) following an essentialist approach. Familiarization was achieved through verbatim transcription and active rereading of transcripts; aspects of the dataset relevant to the research question were noted during this phase. The generation of codes followed an inductive approach, with all aspects of the dataset relevant to the research question being coded, inclusive of those noted during familiarization. Themes were constructed by grouping codes into "patterns of shared meaning" (Braun & Clarke, 2019, p. 592); thematic maps were used to visualize the relationships between themes. All extracts within each candidate theme were reviewed for coherency, and short textual descriptions were produced and compared to identify areas of overlap. The entire dataset was then reviewed to confirm it provided a complete and accurate representation of the data. Analysis was conducted by HC; KS reviewed the dataset and the final report to verify the analysis.

Results

Trial A

To test the hypotheses that watching ornamental fishes would lead to greater reductions in psychophysiological stress and improvements in cognitive performance than resting quietly, and that watching live fishes would have a greater effect than watching videos of fishes, the interaction between condition and time was examined for each dependent variable. No significant condition-by-time interactions were detected for any dimension of mood (positive affect, negative affect, and perceived arousal), physiological stress indicators (blood pressure and salivary cortisol), or directed attention (inhibitory control and working memory) ($p > 0.05$ in all cases). Thus, no evidence was found to support these hypotheses.

The main effect of time was also examined for each dependent variable; although these effects do not relate to the original hypotheses posed, they were of note when combined with the qualitative follow-up analysis and so are reported here. A significant main effect of time was found for positive affect ($p = 0.001$, Figure 2a), negative affect ($p = 0.007$, Figure 2b), systolic blood pressure ($p < 0.001$, Figure 2c), and SCWT-Time ($p < 0.001$, Figure 2d). All were reduced from pre-test to post-test, indicating improved

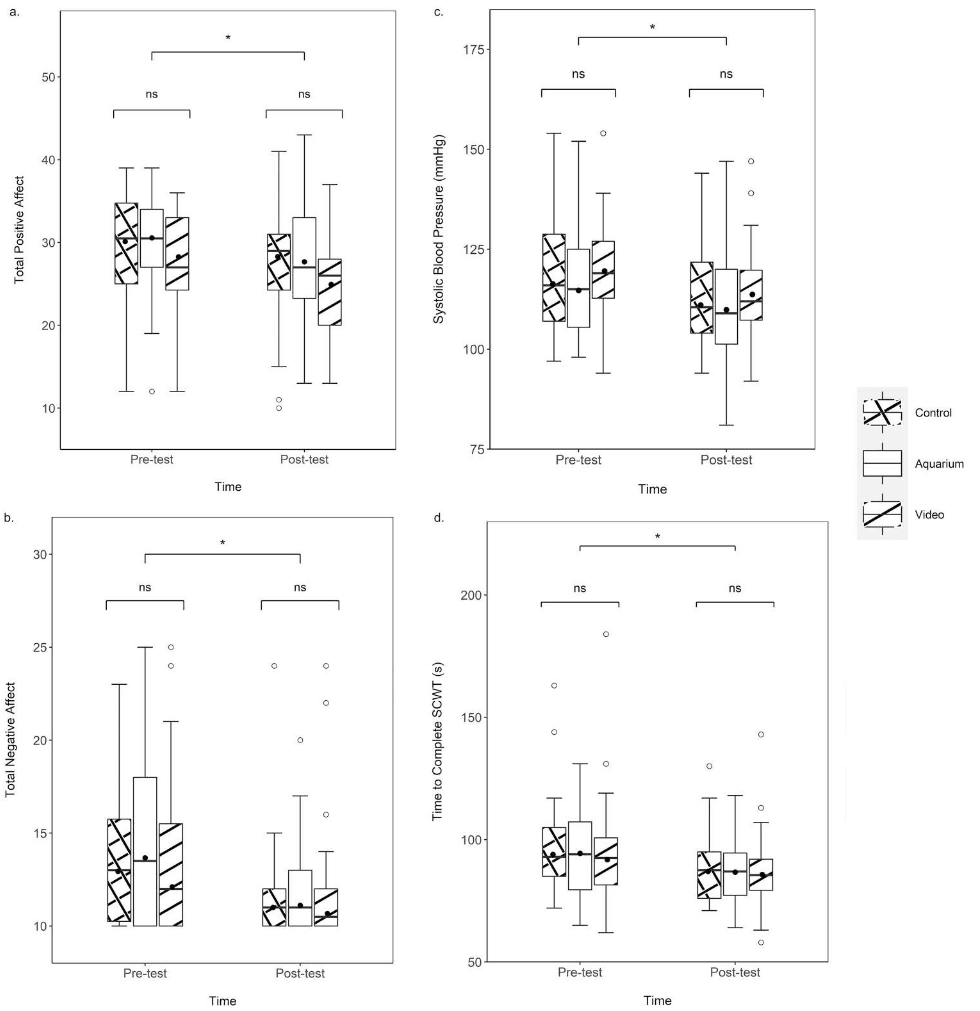

Figure 2. Boxplots showing (a) positive affect, (b) negative affect, (c) systolic blood pressure, and (d) time taken to complete the Stroop Color-Word Test (SCWT) at pre-test and post-test for each condition. Data are 20% trimmed means (black circles), median, interquartile range, and outliers (white circles). $n = 30$, $*p < 0.05$, ns = not significant.

negative affect, systolic blood pressure, and SCWT-Time, and reduced positive affect. No further main effects of time were detected ($p > 0.05$ in all cases).

A significant main effect of condition was found for systolic blood pressure ($p = 0.047$) and DSF ($p = 0.008$). However, these effects appeared to be due to differences between groups at pre-test, so are not discussed further here.

Trial B

To test the hypothesis that repeated viewings of fishes over several weeks would lead to greater improvement in psychological wellbeing than repeated short breaks with no stimulus, the effect of condition was examined for depression, anxiety, stress, and job-related affective wellbeing. All psychological outcomes were significantly predicted by participants' scores at baseline ($b = 0.47–1.01$, $SE = 0.07–0.17$, 95%CI [0.14–0.78, 0.67–1.24]) but not their job satisfaction, so the latter covariate was removed from each model.

Condition did not significantly predict depression, anxiety, or stress, with the 95%CI crossing zero in all comparisons. Condition significantly predicted some aspects of job-related affective wellbeing (Figure 3). Total scores were significantly higher following engagement in the video condition compared with the control condition ($b = 3.67$, $SE = 1.16$, 95%CI [1.10, 5.64]) but not following engagement in the aquarium condition compared with the control condition ($b = 0.88$, $SE = 1.20$, 95%CI [−1.47, 3.23]). The same pattern of results was observed for both the "high pleasure-high arousal" (control vs. aquarium, $b = 0.82$, $SE = 0.48$, 95%CI [−0.13, 1.77]; control vs. video, $b = 0.98$, $SE = 0.47$, 95%CI [0.06, 1.90]) and "high pleasure-low arousal" (control vs. aquarium, $b = −0.04$, $SE = 0.51$, 95%CI [−1.04, 0.97]; control vs. video, $b = 1.33$, $SE = 0.50$, 95%CI [0.36, 2.30]) subscales. Sensitivity analyses indicated that these effects were robust for total job-related affective wellbeing (control vs. aquarium, $b = 0.40$, $SE = 1.24$, 95%CI [−2.03, 2.82]; control vs. video, $b = 3.54$, $SE = 1.24$, 95%CI [1.11, 5.96]) and the "high pleasure-low arousal" subscale (control vs. aquarium, $b = −0.14$, $SE = 0.54$, 95%CI [−1.20, 0.91]; control vs. video, $b = 1.51$, $SE = 0.54$, 95%CI [0.45, 2.56]) but not the "high pleasure-high arousal" subscale (95% CI crossed zero in all cases). Neither the "low pleasure-high arousal" nor the "low pleasure-low arousal" subscales were significantly predicted by engagement in the aquarium or video conditions, with the 95%CI crossing zero in all comparisons. Thus, there was limited support for the hypothesis in terms of psychological wellbeing as some aspects of job-related affective wellbeing were higher following repeated viewings of the fish video. However, as the same effect was not found for repeated viewings of the live fishes, and there was no evidence of an effect for depression, anxiety, or stress, this finding should be treated with caution.

To test the hypothesis that repeated viewings of fishes over several weeks would lead to greater improvement in physiological wellbeing than repeated short breaks with no stimulus, the interaction between condition and time (pre- to post-activity) was examined for systolic and diastolic blood pressure. Results followed the same pattern as for Trial A,

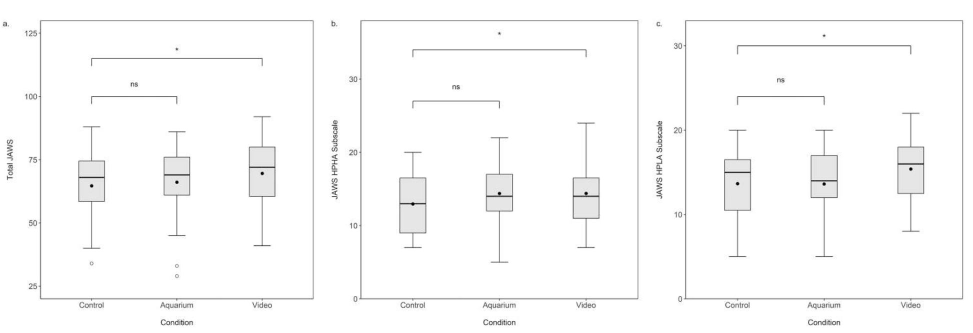

Figure 3. Boxplots showing (a) total job-related affective wellbeing (JAWS), (b) high pleasure-high arousal (HPHA) subscale, and (c) high pleasure-low arousal (HPLA) subscale after engagement in each condition. Data are means (black circles), median, interquartile range, and outliers (white circles). $n = 24$, $*p < 0.05$, ns = not significant.

with no significant condition-by-time interactions observed for either variable. Thus, there was no evidence to support the hypothesis in terms of physiological wellbeing. However, as with Trial A, systolic blood pressure was found to significantly reduce from pre- to post-activity during the testing sessions ($b = -9.59$, $SE = 2.35$, 95%CI [−14.20, −4.97]). No further main effects of time or condition were found (95%CI crossed zero in all cases).

Follow-Up

Three themes were developed from the qualitative data. "*Live fishes are more engaging than videos*" relates to the idea that many participants felt that watching the live fishes was a more pleasurable and immersive experience than watching them on video. "*It was good to get out of the office*" and "*Just taking ten minutes was beneficial*" highlight that many participants experienced benefits from the research that were unrelated to the experimental conditions. These themes provide insight into the quantitative findings and how the implementation of an aquarium-based intervention might best work in practice. A summary of themes is presented in Table 3.

Discussion

This research aimed to investigate whether watching an aquarium during the working day influenced employee wellbeing through the reduction of stress and stress-related outcomes. Previous research shows that watching fishes live or on video may alleviate anxiety and reduce physiological arousal (Buttelmann & Römpke, 2014; Gee et al., 2019; Wells, 2005), and the presence of animals and nature in the workplace is associated with reduced stress (e.g., Barker et al., 2012, Largo-Wight et al., 2011). However, no studies have examined the effects of watching ornamental fishes in a workplace setting. Two experimental trials were conducted under controlled conditions with a sample who took part during their working day and whose occupations are typically associated with higher-than-average rates of work-related stress, anxiety, and depression (Health and Safety Executive, 2020).

In Trial A, it was hypothesized that watching an aquarium would lead to a greater reduction in psychophysiological stress and improvements in cognitive performance than resting quietly for the same period, evidenced by greater improvements in mood and performance on tasks of direct attention, and reductions in perceived arousal and physiological indicators of stress. It was further hypothesized that this effect would be greater after viewing an aquarium containing live fishes compared with a fish video. The data did not support these hypotheses. Although there were improvements in some outcomes (negative affect, systolic blood pressure, and time taken to complete the SCWT) from pre- to post-activity, no significant condition-by-time interactions were detected for any outcome.

Similar patterns of results have been observed in past research. DeSchriver and Riddick (1990) found that viewing a live-fish aquarium or fish video had no greater impact on physiological arousal than viewing a placebo video, but all conditions were perceived to be relaxing. Cracknell et al. (2016) found that observing a public aquarium exhibit led to improvements in mood over time, but the effects did not significantly differ by

Table 3. Summary table of themes developed via reflexive thematic analysis.

Theme	Description	Example quotations
Live fishes are more engaging than videos	Watching live fishes was viewed as a calming activity, which also provided interest and stimulation. By comparison, the video was seen as lacking "something," despite being recognized as visually similar to the aquarium. Several participants conveyed a connection to the live fishes that was not present in the video. Some participants commented on the sound of the aquarium, and one commented on the smell, so the lack of a quantitative effect may have been due in part to factors associated with the presence of a fish tank other than watching the fishes.	"it doesn't make sense why watching a video or watching them live would be any different, but I definitely felt more engaged with watching the live fish than the video" (Participant 5, Focus Group 1, Trial A) "although it was interesting even in the video to watch their behaviour, yeah it's not that same as watching live fish or live animals is it?" (Participant 8, Focus Group 4, Trial B) "I started imagining they had little communities and there was like a bully fish and there was a big fat fish, and it was like 'what's going on with them?'" (Participant 10, Focus Group 3, Trial B)
It was good to get out of the office	Participants had to walk from their office to the testing location, and this appeared to provide them psychological distance from their work. This in itself had benefits, with some likening it to the difference between taking a break and eating lunch at their desk. Some participants felt the presence of an aquarium in a break room opposed to an office may be more effective due to this reason. However, many also felt that the presence of a fish tank or video within the office may be effective at providing momentary relief from work, provided it was large enough to promote a sense of immersion.	"it was good to come to somewhere totally different where I wasn't going to meet anybody from my office or anybody who was going to be asking any questions or starting up any conversations, it was absolutely separate which was good" (Participant 8, Focus Group 4, Trial B) "I think having the ability to go away somewhere specific and kind of yeah, immerse yourself and have a bit more of an experience would make it a bit more novel and a bit more unique" (Participant 1, Focus Group 1, Trial B)
Just taking ten minutes was beneficial	Several participants expressed that taking time out of work was an unfamiliar concept, with the idea of "doing nothing" (as in the control) being completely alien. Some found this a pleasant and relaxing experience, whereas others found it stressful and spent the time thinking about work and feeling guilty about taking time away from their desk; the latter group expressed a clear preference for the live fishes or video as it gave them a point of focus. Being part of a research project helped alleviate this guilt as it allowed participants to schedule sessions into their diary and so they felt they could better justify their use of time. Thus, some participants appear to have found benefit from all three conditions, perhaps partially explaining the lack of an effect in the quantitative results.	"I actually found it quite stressful sitting staring at a blank wall because I started to think about all the things I should be doing and where I should be and what I should be catching up on" (Participant 4, Focus Group 1, Trial A) "having that time out, even just for that short time every week I think really helped, and it was definitely worthwhile" (Participant 9, Focus Group 3, Trial B) "the thing that I found most useful from the experiment was allocating the time on my calendar where I was out of my office, I was doing something and it can be seen that I was doing something and I wasn't expected to answer emails or do anything else" (Participant 7, Focus Group 1, Trial A)

stocking level (unstocked, partially stocked, or fully stocked). Gee et al. (2019) identified significantly greater perceptions of relaxation and mood following observation of a live-fish aquarium compared with observation of an empty tank or one containing only plants, but no consistent effects were identified for physiological outcomes. Thus, watching ornamental fishes might be associated with improvements in psychological, physiological, and/or cognitive outcomes, but these effects may be no greater than those of resting quietly with no stimulus. This contradicts SRT and ART, which would suggest that exposure to nature leads to greater restoration: reduced psychophysiological stress and recovered directed attention resources. One possible explanation for this finding is that the benefits of aquaria go beyond the visual dimension. Several participants in the current study noted that the sound of the aquarium filter enhanced relaxation, which corresponds with past research showing that natural sounds promote restoration (Franco et al., 2017). As this sound was present during all conditions, it is possible that restoration through exposure to nature was experienced by participants in all conditions, including the control. Further research is needed to understand how the effects of watching fishes might be influenced by engaging senses other than sight.

In Trial B, it was hypothesized that repeated observation of the fishes over several weeks would lead to greater improvements in psychological and physiological stress-related outcomes than repeatedly engaging in the control condition. Watching the live aquarium was again predicted to have a greater effect than watching the video. The findings were less straightforward than for Trial A. There was no evidence that watching the live aquarium had a greater impact on psychological or physiological outcomes than the control condition; however, watching the fish video was associated with significantly higher scores for job-related affective wellbeing. Further examination indicated this effect was owing to higher scores for the "high pleasure-low arousal" subscale; an effect was also detected for the "high pleasure-high arousal" subscale, but a sensitivity analysis indicated this effect was not robust.

It is not clear why watching videos of fishes, but not live fishes, would be associated with an increase in high pleasure-low arousal emotions, particularly as qualitative follow-up data indicated that participants tended to prefer watching the live fishes to the video, and research on restorative environments suggests that exposure to actual nature may have more positive effects than exposure to simulated nature (Browning et al., 2020; Reese et al., 2022). ART (Kaplan, 1995) draws a distinction between hard fascination and soft fascination; both refer to stimuli effortlessly capturing attention and so supporting the restoration of directed attention capacity. However, while hard fascination requires complete attention, soft fascination leaves scope for reflection and the processing of internal noise, which enhances the restorative experience (Basu et al., 2019; Kaplan & Berman, 2010). Although theory implies that watching fishes involves soft fascination, the qualitative data suggests that participants found the live fishes more engaging than the video. Perhaps the novelty of the live animals demanded more attention than watching the same animals on video, thus impeding the opportunity for reflection. Further research is needed to determine whether the effects of watching fishes may be influenced by the novelty of the activity. Relatedly, current fish guardianship may influence how participants respond to the activity of watching fishes. For example, those who keep fish may find the activity less novel or may exhibit higher levels of interest owing to their own fish-keeping hobby.

The qualitative data indicated that many participants found taking part in the research beneficial irrespective of the activity completed during sessions, perhaps because the change of location provided an opportunity to experience psychological distance from work. Consistently, research shows that psychological detachment from work, including refraining from job-related activities and job-related thoughts, promotes recovery from work (Sonnentag, 2012). Psychological detachment typically refers to recovery during non-work hours but can also be achieved at work during rest breaks (Sonnentag & Fritz, 2015). Some participants appeared to achieve psychological detachment across all conditions, but this was not universal, and several reported finding the control condition stressful. Consistent with the theory that animals promote wellbeing by capturing attention and diverting it away from negative states (Beetz, 2017), these participants seemed to prefer the two fish conditions as they provided an alternative point of focus. Further research is needed to identify whether watching fishes during rest breaks has a greater impact on wellbeing for employees who find it difficult to detach from work.

It is noteworthy that the control condition used in this study did not reflect a break that would typically be experienced within the workplace; participants rested quietly with no external stimuli. Activities undertaken during a rest break can influence the effectiveness of that break (Fritz et al., 2013). Smartphone use, for instance, has been linked to a lower reduction in emotional exhaustion than break activities such as napping or walking (Rhee & Kim, 2016), while the use of a laptop can counteract the beneficial effects of nature exposure on attention (Jiang et al., 2019). Therefore, different effects may be observed where rest breaks are self-directed. The qualitative data indicated that live fishes were more engaging than the video, which is consistent with research showing that live fishes readily capture and hold human attention (Cracknell et al., 2016; Windhager et al., 2011). Therefore, the presence of fishes in a breakroom might be beneficial if they capture attention and divert it away from electronic devices. Similarly, aquaria located within the office may encourage microbreaks: short, informal breaks which occur spontaneously during work but are not directly related to work activities (Fritz et al., 2011; Henning et al., 1989; Lee et al., 2015).

This was the first study to investigate the impact of watching ornamental fishes on cognitive performance. Previous research demonstrates that interaction with dogs and cats may influence cognition (Allen et al., 2001; Gee et al., 2015; Stewart & Strickland, 2013), and theories of restoration predict that exposure to nature enhances cognitive performance. Therefore, it is important to understand under which circumstances (if any) engagement with ornamental fishes may have similar effects.

The use of a controlled level of exposure to the fishes was both a strength and a weakness. The theoretical frameworks on which this research was based suggest that any benefits associated with ornamental fishes occur primarily through visual exposure. Thus, controlling exposure prevented other factors associated with the presence of an aquarium in the workplace from influencing study findings. However, this level of engagement is unlikely to reflect how employees would engage with ornamental fishes in their workplace. Previously, a greater trend toward relaxation was observed among older adults who were given goldfish to care for at home, versus those who received visits from the researcher or had no intervention (Riddick, 1985). Thus, being involved in fish-care activities may lead to greater effects than visual exposure alone. The level of exposure and the timing of assessments may have also influenced the findings of this study; a longer duration of Trial B may have been beneficial in detecting changes in longer-term outcomes such as depression or anxiety, and an effect on levels of cortisol may have been detected in Trial A had there been a greater delay between watching the fishes and collection of saliva samples. Further research is needed to understand the ways in which people engage with fishes at work, how this may influence employee wellbeing, and how the level of exposure and timing of assessments may influence the observed results.

Participants identifying that live fishes were more engaging than the video was a key finding from the qualitative data. However, HAI research is subject to self-selection biases; typically, only individuals who enjoy interacting with animals will participate (Friedmann & Gee, 2019). This was likely exaggerated within the qualitative aspect of this research, as social desirability biases may have prevented individuals with less positive opinions from participating in the follow-up. In future research, this could be overcome by obtaining anonymous feedback from all participants or specifically recruiting people with less positive attitudes toward animals.

Conclusions

The findings of this research did not support the premise that watching live fishes in the workplace has a greater impact on employee stress and stress-related outcomes than watching a fish video or resting quietly. Conversely, repeatedly viewing fish videos over several weeks was associated with greater job-related affective wellbeing, specifically in relation to high pleasure-low arousal emotions. The reason for this finding is unclear; possibly the less engaging nature of the fish video placed lesser demands on the attention of participants than watching the live fishes, thus allowing them the mental space needed to engage in reflection. Further research is needed to examine this theory and to provide a deeper understanding of exactly how employees engage with fishes in the workplace and whether this engagement influences employee wellbeing and cognition.

Disclosure Statement

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