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Aims & Scope

The International Journal of Neuropsychotherapy (IJNPT) is an open access, online journal that considers manuscripts on all aspects of integrative, biopsychosocial issues related to psychotherapy. The IJNPT aims to explore the neurological or other biological underpinnings of mental states and disorders to advance the therapeutic practice of psychotherapy.

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Building Resilience Through a Virtual Coach Called Driven: Longitudinal Pilot Study and the Neuroscience of Small, Frequent Learning Tasks

Jurie G. Rossouw, Chelsea L. Erieau, and Eric T. Beeson

Abstract

Background
Digital interventions hold promise to address the global decline in mental health. Resilience is indicated as an avenue to enact preventative care. Combining resilience enhancement with a neuroscience-based learning technique may attenuate current trends.

Objective
This study sets out the neurobiological mechanics of small, micro-session learning (microtasks), and tested their efficacy in building resilience capacity through a digital conversive program called Driven to create lasting behavioral change.

Methods
Using the foundations of the microtask approach, Driven was constructed as an automated intervention to improve resilience capacity, based on the PR6 resilience framework. Real-world data from a sub-clinical cohort (N=387) across four organizations were analysed using the PR6 resilience psychometric to assess resilience pre and post intervention. Usage rates of Driven and other factors were investigated through regression analyses as predictors of future resilience capacity improvement.

Results
Of the invited cohort, 89% (N=345/387) participated and were mostly male (74.5%, n=257/345). Median time between first and second PR6 assessment was 199 days. Of these participants, 70.4% (n=245/345) completed the second assessment. The average individual improvement in resilience was 10.9% for the remeasured cohort (n=245). Results showed higher daily usage of Driven resulted in greater resilience improvements, with usage of more than once every four days resulting in a 15.6% improvement, and average usage once every two days resulting in a 24.9% improvement. Low or no usage of Driven showed no significant improvement. Further, a lower pre-intervention score resulted in higher participation and higher subsequent improvement.

Conclusion
Delivering microtasks through a digital virtual coaching approach presents a reliable method to achieve lasting behavioral change and improve resilience capacity. Additionally, Driven displays an ability to provide effective preventative intervention to those with greater need.

Keywords: resilience, professional coaching, virtual coaching, neuroscience, learning, neuroplasticity

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Worldwide, 1 in 13 people suffer from anxiety, and estimates hold a prevalence of 4%–5% across 53 countries. In Australia, this number increases 1 in 7, while 1 in 5 have experienced a mental disorder in the last 12 months (Australian Bureau of Statistics, 2007). 300 million people are estimated to suffer from depression, contributing to around 800,000 suicides each year (World Health Organization, 2018).

Depression and anxiety alone cost the global economy an estimated US$1 trillion in lost productivity each year—equivalent to 12 billion days or 50 million years of work (Chisholm et al., 2016). There is an evident need for new preventative interventions that can be more broadly applied to de-escalate early depression and "inoculate" individuals against depression, anxiety, and stress (Katz et al., 2016).

The need for this is clear when considering an estimated US$2.5–8.5 trillion in lost output due to mental, neurological, and substance-use disorders —a number predicated to double by 2030 unless substantial effort is directed at the problem. In terms of cost-benefit analysis, current cost-benefit research indicates that for every $1USD put into scaled up treatment for mental disorders, the net benefit is up to $5.7USD return in increased health and productivity (Chisholm et al, 2016).

Self-reported absenteeism is halved in workplaces that the employees have reported as mentally healthy. This is important to note when one in five Australian workers reported having taken time off for their mental health in the past 12 months in 2007 (Australian Bureau of Statistics, 2007). In the UK, 12.7% of all sickness absence days is attributable to mental health (Office for National Statistics, 2014). Research by Miller shows that 82% of employees with mental health issues report that it affects their work, compared to 53% of people with physical health issues (Miller, 2006).

Employees who would describe their workplace as mentally unhealthy are four times as likely to take time off work. However, in Australia only 52% of employees said their workplace is mentally healthy, and only five out of ten (56%) would say their most senior leader cares about mental health—despite 91% of employees reporting that mental health is important in the workplace (ABS, 2007). Untreated mental health conditions lose the Australian workplace $10.9 billion each year—$6.1 billion in presenteeism and $146 million in compensation claims.

Given the magnitude of the problem, more research over the last three decades has focused on the development of resilience as a proactive, protective measure against detrimental mental health states

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(Edward, 2005; Masten, Cutuli, Herbers, & Reed, 2009; Rutter, 1985; Stoffel & Cain, 2018). Resilience can be defined as "the ability to positively adapt and thrive in the face of risk and adversity" (Rossouw & Rossouw, 2016, p. 32). Resilience is a temporal, multidimensional concept and exists in multiple expressions across all cultures and generations (Connor & Davidson, 2003). It is not necessarily a personality trait; rather, it can be a learned set of cognitive skills and beliefs that enable action and minimize harm when affected by stressors. Resilience is an important aspect of goal achievement, being a better predictor than IQ or talent, and acts as a protective factor for children in stressful environments (Garmezy, 1985a, 1985b; Tsuang, 2000). People who are more resilient make fewer career changes than their same-age counterparts (Duckworth, Peterson, Matthews, & Kelly, 2007) and are more likely to stick with a difficult job (Eskreis-Winkler, Duckworth, Shulman, & Beal, 2014). Research conclusively shows that the psychological wellbeing of the workforce is directly related to work-related outcomes, in both the individual and organizational spheres (Ford, Cerasoli, Higgins, & Decesare, 2011; Taris & Schreurs, 2009).

Thus, developing resilience in the workforce and the population at large may be an effective pathway to preventing lost productivity and improving the psychological health of the general population (Robertson, Cooper, Sarkar, & Curran, 2015). A carefully designed, proactive intervention is much more cost-effective than a retroactive solution (Luthar & Cicchetti, 2000; Yoshikawa, 1994; Yoshikawa & Knitzer, 1997), hence resilience should be developed through preventative methods.

Research is emerging on the efficacy of digital intervention as a scalable solution to wide-ranging issues including AIDS (Ybarra & Bull, 2007), smoking cessation (Rodgers et al., 2005), health promotion and disease control (McFarlane, Kachur, Klausner, Roland, & Cohen, 2005), contraceptive method choice (Garbers et al., 2012), and even sexual counselling after prostate cancer treatment (Schover et al., 2012). Digital intervention has proven effective in several mental health and somatic-related issues, including IBS (Andersson et al., 2011), tinnitus (Kaldo et al., 2013), and depression (Kaltenthaler, Parry, Beverley, & Ferriter, 2008). This represents an interesting possibility of addressing a widescale problem quickly at an individual and population level. Digital intervention represents a potential avenue to developing resilience in the workforce and the general population.

Further, people are steadily becoming "digital natives." In Australia in 2018, smartphone ownership stood at 89%, which rose from 88% in 2017 and 84% the year before (Mobile Consumer Survey, 2018). The largest usage increase is from users 55 and over. This is close to the peak saturation point of smart device use (predicted as 90%–95%). Engagement with digital voice assistants has risen significantly, meaning that people may be becoming more reliant on, and comfortable with, automated interaction (Deloitte, 2018). Given such a large percentage of the population have access to a common channel for learning—which is set to continue increasing—it seems wise to capitalize on that particular mode.

Murray et al. (2016) have put forward a case that digital health interventions present an opportunity for cost-effective and scalable solutions in a resource-scarce environment, and that an actionable knowledge base should be created "in a timely manner" to facilitate urgently needed solutions (p. 844). Our aim is to contribute to this knowledge base by investigating the efficacy of a digital artificial intelligence virtual coach, which will be referred to as "Driven" for the remainder of this paper. Driven aims to provide a scalable, accessible model of resilience training through daily activities, using a digital format to assess and intervene.

Design of Driven

Developing the Concept of Microtasks

Traditional approaches to resilience development involve workshops and in-person facilitation, commonly utilizing experiential learning (Kolb, 2015). While this style has particular strengths, limitations regarding budgetary and time availability restrictions result in lower organizational deployment. Further, resilience consists of various personal skills (Olsson, Bond, Burns, Vella-Brodrick, & Sawyer, 2003; Rutter, 1985), that may take a longer timeframe to develop, and is therefore not suited to one-off training styles.

As such, in designing the style of resilience development, a modality was sought that has a strong potential of achieving individual behavioral change through an automated approach. Participants would thereby have increased opportunity to internalize the diverse set of resilience skills, allowing neural change while at the same time achieving scalability to reach larger audiences at lower cost. In order to design such an approach, a review of learning approaches in combination with neuroplasticity was conducted.

Neuroplasticity in relation to learning. Functional plasticity involves corrective processes where brain functions are remapped following neural damage to brain tissue (Freed, de Medinaceli, & Wyatt, 1985). Structural plasticity involves synaptic gain and elimination (restructuring) to integrate learning through memory trace formation (Caroni, Donato, & Muller, 2012). As resilience development in subclinical populations do not involve functional rewiring, we can generally conclude that structural plasticity is of primary interest in facilitating long-term memory formation and behavioral change (Chklovskii, Mel, & Svoboda, 2004; Lamprecht & LeDoux, 2004). Structural plasticity in association cortices is mediated through hippocampal function that stores short to medium-term learning for consolidation and integration (Abraham, Logan, Greenwood, & Dragunow, 2002; Leuner, & Gould, 2010).

Structural plasticity is influenced by long-term potentiation (LTP), starting with co-incident pre- and postsynaptic firing, resulting in activation of N-methyl-d-aspartate (NMDA)-type glutamate receptors, release of the Mg^{2+} blocks, influx of Ca^{2+}, triggering postsynaptic release of protein kinases such as CaMKII and PKC (Lüscher & Malenka, 2012). This further causes phosphorylation reactions that traffics postsynaptic recycling endosomes to insert AMPA receptors into the postsynaptic spine, rendering the synapse more sensitive to future presynaptic firing.

In the later stage of LTP, CREB gene transcription processes are activated via cAMP and PKA, resulting in protein synthesis that is necessary for the production of new dendritic spines that enables the possibility for LTP to occur (Engert & Bonhoeffer, 1999; Kandel, 2001). Further optimization of neural pathway structuring is achieved through spike timing-dependent plasticity (STDP), where LTP is only enabled where the presynaptic terminal fires before the postsynaptic terminal within a window of 20 milliseconds (Bi & Poo, 1998).

Of interest for the development of an efficient learning mechanism is the method by which the presynaptic terminal releases neurotransmitters into the synaptic cleft. Rapid release and reuptake of neurotransmitters is best suited to achieve STDP and facilitate structural plasticity. Clathrin-mediated endocytosis may be too slow to facilitate this, however Watanabe's work that demonstrated ultrafast endocytosis without the need for clathrin may be more prevalent at body temperature, while clathrin-mediated endocytosis is more prevalent at room temperature (Brockmann & Rosenmund, 2016; Watanabe et al., 2013). This provides a basis for more frequent neurotransmitter recycling, turning our attention to exocytosis.

Recently, a process of spontaneous exocytosis from the presynaptic terminal was described by Cho et al. (2015). This showed that the fusion clamp Complexin in the SNARE complex undergoes activity-dependent phosphorylation, resulting in increased ongoing spontaneous neurotransmitter release following activation (Cho et al., 2015). They conclude that this process plays a key role in structural plasticity through facilitating formation of synaptic boutons.

This builds towards a further conclusion that frequency of pathway activation plays a role in pathway change, which has subsequently been demonstrated by Lea-Carnall, Trujillo-Barreto, Montemurro, El-Deredy, & Parkes (2017) through their work on frequency-dependent plasticity (FDP) in larger scale networks (Lea-Carnall et al., 2017). However, the mechanics and relevance of how FDP exactly contributes to broader cognitive pathway change is still poorly understood at the current stage. Nevertheless, the concept of FDP provides a glimpse into further mechanistic explanations of how tuning of learning frequency may enhance learning and LTP.

Many other neural structures are implicated in memory and habit formation, such as the nucleus accumbens and ventral tegmental area (habits, addiction, reward pathways), cerebellum (fine motor movement, motor-related learning), amygdala alongside the hypothalamic pituitary adrenal axis (fear-based learning). The full neural mechanism of learning is complex and not comprehensively understood, so for the purpose of this review we will keep our focus to structures and functions that are most pertinent to the concept.

Importance of BDNF for learning. Our previous research (Rossouw & Rossouw, 2016) noted the importance of brain-derived neurotrophic factor

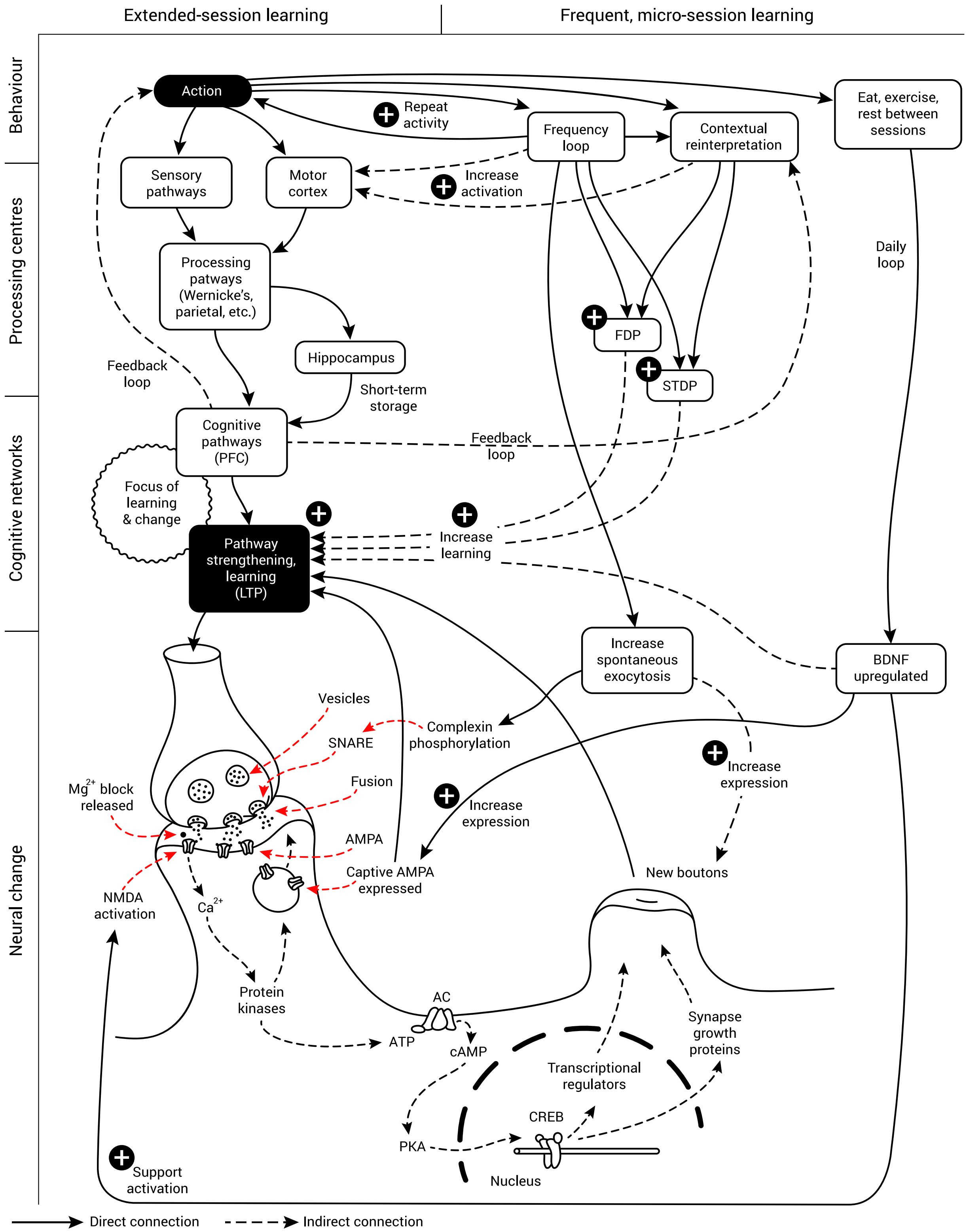


Figure 1. Learning style influence on structural plasticity: relationship map crossing from behavior, into processing centres, into cognitive networks (the target for learning), through to neural change mechanisms. Arrows indicate direct relationships (solid lines) and indirect effects (dashed lines). Normal extended-session learning is presented on the left half, with mechanistic impacts on learning effectiveness presented on the right half through frequent, micro-session learning. Plus '+' signs indicate avenues for increased learning due to frequent, micro-session style learning. PFC = prefrontal cortex; LTP = long-term potentiation; FDP = frequency-dependent plasticity; STDP = spike-timing dependent plasticity; BDNF = brain-derived neurotrophic factor; AMPA = α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid; NMDA = N-Methyl-D-aspartic acid; SNARE = soluble NSF attachment protein receptor; ATP = adenosine triphosphate; cAMP = cyclic adenosine monophosphate; AC = adenylyl cyclase; PKA = protein kinase A; CREB = cAMP response element-binding protein.

(BDNF) for synaptic structural plasticity (Leal, Bramham, & Duarte, 2017; Lu, Nagappan, & Lu, 2014), alongside the importance of BDNF in behavioral adaptation (Castrén & Rantamäki, 2010; Lu, Nagappan, Guan, Nathan, & Wren, 2013). BDNF is shown to upregulate NDMA activation (Mizuno, Yamada, He, Nakajima, & Nabeshima, 2003), alongside increasing activation and expression of captive AMPA receptors (Caldeira et al., 2012; Wu et al., 2004). Therefore we note the importance of the presence of BDNF for structural plasticity and neural adaptation in relation to resilience skill learning.

Various factors influence the regulation of BDNF, including regular physical exercise which upregulates BDNF and hippocampal function (Cassilhas et al., 2012; Cotman & Berchtold, 2002). Poor nutrition in the form of high sugar combined with dietary fats and alcohol has been slow to downregulate BDNF (Heffernan, 2008; Molteni, Barnard, Ying, Roberts, & Gomez-Pinilla, 2002). Sleep hygiene is also indicated to influence BDNF levels (Giese et al., 2013; Monteiro et al., 2017). Collectively this provides evidence for the necessity to maintain a physiologically healthy lifestyle in order to provide an optimal environment for plasticity to take place.

Figure 1 presents a relationship map of the various factors as they interact. This diagram shows a comparison of how frequent, micro-session learning can impact and improve learning compared to longer, single-session learning. Various mechanistic pathways provide potential for increased learning, enabling further research to consider the extent to which each factor contribute most strongly.

We also note an inverse relationship between cortisol and BDNF (Issa, Wilson, Terry, & Pillai, 2010; Naveen et al., 2016), indicating the likelihood of reduced learning under stress. This link between elevated cortisol levels and reduced learning has been noted in previous studies (Dinse, Kattenstroth, Lenz, Tegenthoff, & Wolf, 2017; Vogel & Schwabe, 2016). The implication of this effect of cortisol was considered in the intervention design.

Intervention conceptual design. The collection of evidence above was consequently considered in the design of the resilience development training intervention. Given the nature of STDP and FDP, combined with spontaneous exocytosis following pathway activation, it followed that shorter, more frequent training activities would provide increased potential for behavioral change. Providing these on a daily schedule may also assist in utilizing BDNF replenishment through sleep processes.

Writing notes when learning has been found to improve retention, particularly when written by hand rather than typing due to handwriting usually involving contextual re-interpretation while typing is more often verbatim (Mueller & Oppenheimer, 2014). Therefore, utilizng a format within which learning is adapted to the individual and driving interaction to require contextual re-interpretation can allow us to utilize on-hand technology such as smartphones to improve retention. Using technology in this context further enables uniquely defined paths based on participant interaction, using decision trees and natural language processing techniques to categorize input and provide deeper contextualized training.

Improved learning may indeed arise from convergent activation of relevant neural pathways through recruitment of language areas (Broca's and Wernicke's) and motor cortices (mechanistic typing actions), combined with interpretation, memory retrieval, and contextual re-interpretation which has been suggested as a mechanism that improves learning (Smoker, Murphy, & Rockwell, 2009). In concert, the combined process of interactive training result in more acute activation of resilience skills areas being trained, resulting in greater STDP and FDP.

From here, the method for resilience skills education builds on the original concepts of micro learning (Buchem & Hamelmann, 2010; Hug, 2005). With the addition of digitally-enabled contextual re-interpretation requirements of learning activities to improve retention and cognitive integration, we distinguish this modality from micro learning and establish the concept of microtasks.

The microtask modality therefore suggests a mechanism that may assist in achieving greater learning through more structural plasticity changes than would be achieved through single condensed learning sessions. This concept can be summarized by this example: Practicing the piano each day for seven days is better for learning than practicing one session that is seven times as long. Even if the same amount of time in total is spent practicing, more synaptic change takes place when the task is broken up. This is due to the increased spontaneous vesicle fusion following each practice session that continues to drive synaptic structural plasticity, combined with the effects of FDP and BDNF replenishment each day.

Defining microtasks. Given this context, we can define a microtask as a short (up to 10 minutes, or more) interactive task that requires active participation through contextual reinterpretation of the learning content. In other words, this means the learner takes the learning content and re-interprets it in their personal context to further engage the mechanisms of structural plasticity to achieve long-term behavioral change.

While we are defining this concept, we do not propose to be the inventors of this. Our interest with this review is to further understand the potential mechanistic learning pathways. This understanding may serve to further improve program design aiming to achieve behavioral change with individuals in various contexts.

Bottom-up approach. Regarding the impact of cortisol and stress on learning, Driven employs a simple initial emotional state / stress check to determine participant receptiveness to learning. If emotional distress was reported, alternative interventions were proposed to assist in enhancing individual composure. These interventions included breathing exercises, reappraisal exercises, and mediations. This bottom-up approach to facilitate limbic brain downregulation was employed at the start of each microtask session in an effort to improve potential for new skill and knowledge integration.

Hypothesis

Our hypothesis is that regular adherence to completion of resilience-related microtasks predicts greater improvement in resilience scores. The objective of this study is to test for this effect through the application of Driven within an organizational context.

Method

Participants

The cohort includes data from four organizations that implemented Driven soon after its introduction in late 2017, as well as having completed both pre- and post-intervention resilience assessment. To best represent a natural "real world" implementation, all participants were included from these organizations that were included in both the pre- and post-assessment. These are generally the full population of a particular organizational department that were nominated for the program as requested by the organization.

The full cohort (*N*=387) was invited by their respective organizations to participate in the Driven resilience program. Participants were 25.5% female (*n*=88) and 74.5% male (*n*=257). No further gender data were available.

The implementation of Driven within these organizations was requested by the organizations themselves and was therefore not externally manipulated for research purposes. This setting provides a basis for a longitudinal observational study, providing insight into a real world implementation of Driven within organizations. Given this setting, comprehensive demographic data on participants were not available, and available data are reported on.

Ethics is controlled through agreed-to service Terms and Conditions, as well as a Privacy Policy (available at https://hellodriven.com/) that ensures individual confidentiality and allows for use of de-identified and aggregated data for research purposes. All participants are provided with contact information for queries related to privacy and to request removal of data.

Given that program implementation was made at arms-length, there was no compensation provided to program participants.

Measures

The Predictive 6 Factor Resilience Scale (PR6) psychometric measurement tool was used for pre- and post-intervention assessment. The PR6 is a validated psychometric that measures resilience across six domains spanning both mental and physiological health factors (Rossouw, Rossouw, Paynter, Ward, & Khnana, 2017). Using a standard 5-point Likert scale across 16 items, the PR6 has shown strong internal consistency (alpha) of 0.84 in previous research.

The six domains of resilience reported in the PR6 have been shown alongside their neurobiological correlates, and are summarized as follows:

- **Vision**—a measure of sense of purpose and clarity of personal goals
- **Composure**—ability to manage stress and regulation of emotional impulses
- **Reasoning**—ability to solve problems, be resourceful, and anticipate and plan for future adversity
- **Tenacity**—ability to maintain persistence, motivation and bounce back from adversity
- **Collaboration**—maintenance and formation of support networks and personal relationships
- **Health**—physiological health, including good nutrition, quality sleep and regular exercise

Given this context, resilience is presented as a collection of skills that coalesce into resilience capacity. Domains within the PR6 are designed as areas that can be learned and improved upon, setting it apart from personality traits which are expected to be stable over time.

The pre-intervention assessment was conducted as the very first interaction that the participant had with the program, providing a robust starting score that is not influenced by any training content. Participants completed the PR6 assessment online on the Driven platform through an internet-connected device, such as a laptop or smartphone. On completion, participants received a resilience reports that displayed scores across the six domains. From there they were able to continue to the training content.

Intervention

The Driven resilience development program employs approximately 200 microtasks to facilitate resilience skills building, enabled through a virtual coaching approach that uses an AI-powered chatbot alongside decision trees and a mix of interactive content.

Resilience domains of the PR6 provided the basis for the development of microtasks provided through Driven. Each microtask activity is based on research conducted into relevant psychological and neuroscience concepts that support the relevant resilience domain.

Content includes a mix of new research alongside time-tested strategies to provide comprehensive approach to build resilience capacity. Resilience-training content includes education on the effects of personal interpretation bias and mitigation (Berna, Lang, Goodwin, & Holmes, 2011; Kleim, Thörn, & Ehlert, 2014), education on emotional granularity and mood restoration techniques alongside practice (Fredrickson & Branigan, 2005; Tugade, Fredrickson, & Barrett, 2004), motivation techniques through goal setting (Clarke et al., 2014) including Duckworth et al.'s work on grit (Duckworth, Peterson, Matthews, & Kelly, 2007), and mindfulness techniques to aid in managing and preventing depressive symptomology (Mason & Hargreaves, 2001; Teasdale et al, 2000) alongside various CBT-style activities, drawing on the well-established nature of CBT and recent evidence suggesting the effectiveness of digitally-delivered intervention (Jakobsen, Andersson, Havik, & Nordgreen, 2017).

Relating to physiological health, content includes general education on constructing a home environment conducive to good sleep, nutrition education information and activities, exercise suggestions and content to encourage physical fitness, alongside journaling activities to promote self-monitoring of change (Hollis et al., 2008).

Further to the sample of research listed above and other research consulted relating to the development of the microtasks, the PR6 and Driven is also supported by a science advisory board and is used by over 200 psychologists, counsellors, and coaches who have provided feedback into the program itself. Content is prioritized based on how the participant scored in the pre-assessment, focusing initial user activity on lowest scoring domains.

Participants were free to interact with Driven as often as they liked, and received periodic notifications to suggest continuation with the training, such as one notification after 24 hours, and if there is no activity, another after 48 hours, and so on. These notifications could be disabled if needed, and also subside over time if there is a lack of participation.

To maintain confidentiality of data and data control, Driven is delivered through a proprietary platform that can be accessed on any Internet-enabled device. This contrasts with other services that use delivery platforms, such as Slack and Facebook Messenger, where the data is also owned by the delivery platform through their own terms of service.

At the start of the program, it is explained to participants that Driven is not a crisis service, and is not intended as a replacement for medical advice or in-person therapy. Should a participant require immediate help, crisis helplines are provided across various help types to assist in finding appropriate assistance.

In essence, Driven is developed as an evidence-based resilience building platform with validated psychometrics built in to create meaningful change over time. Given the potential of digital interventions like Driven to build resilience at scale and function as a preventative intervention against depression and anxiety, we consider the results of this study to carry importance.

Organizational Application

At a point in time, generally around six to seven months, chosen by the organization, a re-assessment was initiated. These varied per organization and within organizations as different teams were enrolled and assessed at different times. This took the form of a notification sent to all participants still with the organization at the time, after which the assessment was unlocked, and participants had the opportunity to complete the PR6 again to measure change since the previous assessment.

Natural attrition arose here due to employees who had left the company, employees on annual or sick or other leave, or employees who chose not to participate in the re-assessment. Once again, on completion the participant received a report that then compared the previous score to the new score to assist in identifying change. As there are many factors that influence resilience, a natural variance is expected in scores, particularly since these are domains designed to be improvable.

Data for Analysis

Observational data included pre- and post-intervention PR6 resilience scores, duration between assessments, gender demographics, company of participants, alongside usage data to determine completion of microtasks.

De-identified data were extracted from the Driven platform to conduct statistical analysis. Data were tested for normality, internal consistency of the pre- and post PR6 assessments was conducted, ANOVA and *t*-tests were conducted to determine statistical significance. Single and multiple regression analyses were conducted to investigate potential predictive factors.

Results

Of the full cohort, 345 (89.1%) participated in the initial assessment and 42 (10.9%) did not.

First Assessment

PR6 resilience score achieved for all the participants in the first assessment (n=345) was 0.69 (StDev 0.134), assessing resilience between 0 (lowest resilience) and 1 (highest resilience). Using the Ryan-Joiner normality test, normality was confirmed with a RJ value of 0.996 (p-value = 0.045).

Starting PR6 scores ANOVA testing showed no statistically significant differences (p-value = 0.161) between genders, with females scoring (PR6=0.67, StDev=0.134, n=88), and males (PR6=0.7, StDev=0.134, n=257). Internal consistency of the PR6 was strong with an alpha of 0.7815 (n=345). Differences were noted in the starting points of the four companies, notably with company 4 (C4) displaying a higher starting point (PR6 = 0.79, 95% CI = 0.75 to 0.82), which when removed eliminated any significant difference and also improved overall results. However, to avoid overspecialization and display broader generalizability of the results, C4 data was included in further analysis.

Second Assessment

Following the initial assessment, organizations triggered second assessments at various times according to their own requirements. Median time between assessments was 199 days, with a mean of 193 days (StDev = 61 days). This provided considerable data to measure longitudinal adherence to a digital platform, where often studies are very short-term oriented due to high attrition rates.

Of the initial participants, 70.4% (n=245) completed the second assessment. Attrition reasons included participants that left the company, was on leave, or chose not to participate. Data on reason were not available. ANOVA testing of those who completed the first assessment only (PR6 score = 0.693) and those who participated in re-assessment (PR6 score = 0.688) showed no significant difference in starting scores (p-value = 0.771). Ryan-Joiner normality test again confirmed normality for the second assessment with a RJ value of 0.989 (p-value = <0.01).

PR6 Remeasurement (PR6-R) overall score for participants (n=245) was 0.75 (StDev=0.13), indicating an overall relative increase in resilience of 8.3% regardless of usage. ANOVA confirmed significance of the overall increase in resilience (p-value = <0.001; Cohen's d = 0.27). When analysing by gender, no statistical significance (p-value = 0.53) was found between females (PR6-R=0.738; StDev=0.112; n=72) and males (PR6-R=0.748; StDev=0.133; n=173). Internal consistency of the PR6-R was strong with an alpha of 0.7964 (n=245).

When analyzing by individual change experienced, we find an average increase of 10.7% (StDev=0.23) across the reassessment cohort (n=245). As this value is higher than the absolute increase, we consider greater increase experienced by those who scored lower initially.

Gender-based improvement. Comparing by gender, we see females experience on average a 16% improvement (StDev=0.28), while males experience on average an 8.4% improvement (StDev=0.2). This difference was found to be statistically significant (p-value = 0.036).

Usage rates. Completion rates of Driven microtasks were recorded and were used to calculate average engagement ratios. For analysis purposes, these were condensed into five usage groups:

- **Recommended Usage** (RU), indicating sustained used of Driven on average once per day
- **High Usage** (HU), indicating usage of Driven on average once every two days
- **Moderate Usage** (MU), indicating average usage once every four days
- **Low Usage** (LU), indicating average usage less than MU
- **No Usage** (NU), indicating no usage other than completing pre- and post-assessments

Through this approach, LU and NU serve as control groups against generally higher usage groups MU, HU, and RU. Comparing differences between usage patterns should provide insight into the hypothesis of more microtask completion leading to further increase in resilience scores.

Compared to starting scores, we see a clear upward trend in score improvement based on participation rate. ANOVA analysis confirmed statistical significance of resilience improvement compared to usage (p=<0.001).

Across these we observe groupings with largest participation in MU (n=85), followed by LU (n=66), and NU (n=65), then HU (n=24) and RU (n=5). NU and LU groups showed minor improvement, however these groups did not achieve significance (NU p=0.562, Cohen's d = 0.06, LU p=0.483, Cohen's d = 0.08). MU and HU shows a clear progressive trend that resilience scores increase from higher usage (MU p=<0.001, Cohen's d = 0.41, HU p=<0.001, Cohen's d = 0.73). Due to the lower number of participants in RU, the p-value did not achieve significance, however the general trend holds with this pilot evidence (Cohen's d = 0.73).

Table 1
Usage Rates and Change

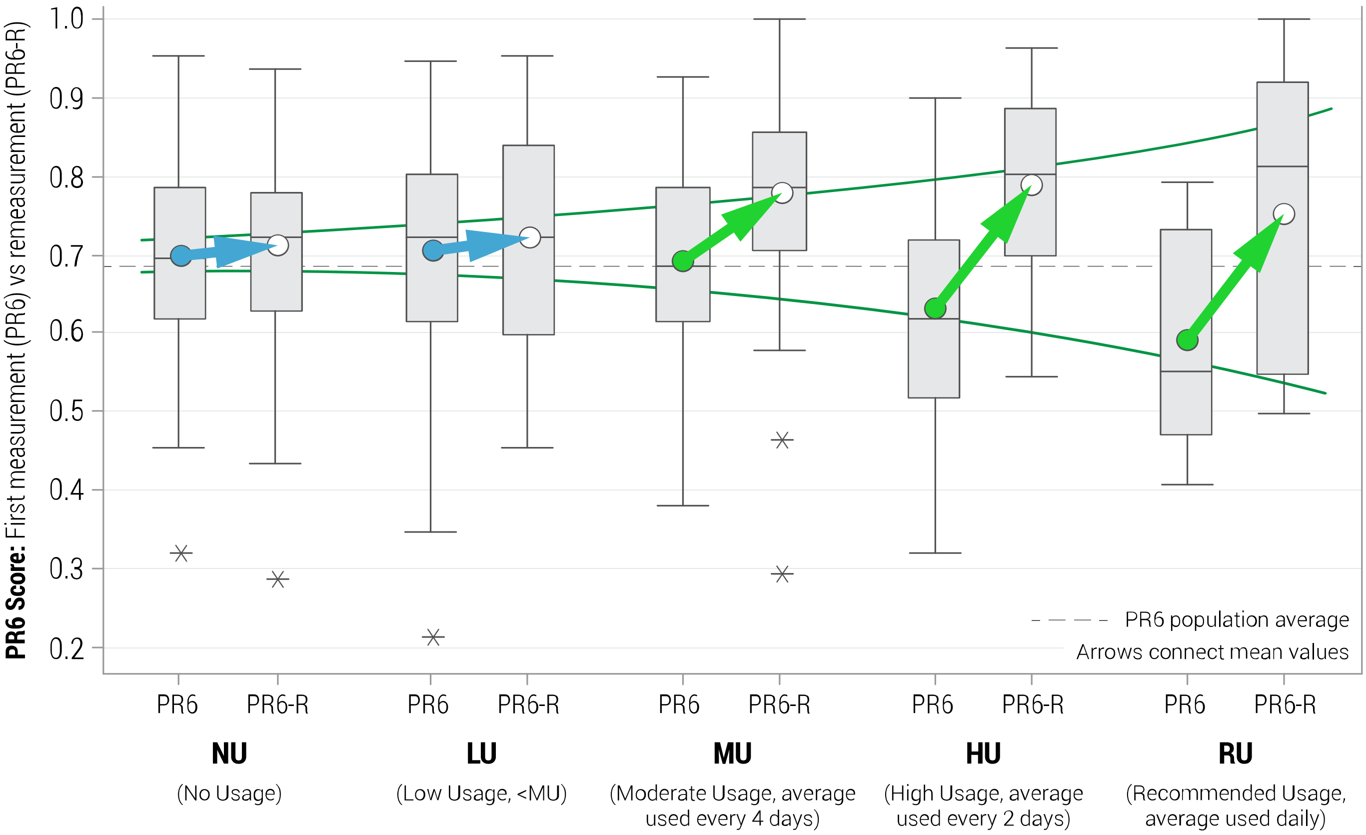
Usage	PR6	PR6-R	Improvement	P-value
NU	0.698	0.711	1.8%	0.562
LU	0.705	0.722	2.4%	0.483
MU	0.69	0.778	12.7%	< 0.001
HU	0.63	0.787	24.9%	< 0.001
RU	0.593	0.75	26.5%	0.198

Note. NU = no usage; LU = low usage; MU = moderate usage; HU = high usage; RU = recommended usage.

Interestingly, we also see a trend that lower scores correlate to higher usage rates alongside greater increase experienced through the program. Usage rates and percentage of individual change from PR6 starting score to PR6-R is summarized in Table 1, showing a general upward trend in improvement by usage. This effect is illustrated by the box plots

Graph 1

Higher Usages Increase PR6 Score



Note. PR6 = First Predictive 6 Factor Resilience Scale assessment; PR6-R_ = second PR6 assessment; NU = no usage; LU = low usage; MU = moderate usage; HU = high usage; RU = recommended usage; blue arrows show no significant change; green arrows show larger change.

in Graph 1, showing pre- and post-intervention assessment for each usage group.

Analyzing across genders, no statistically significant difference in usage was found (p-value = 0.716).

PR6 domain improvement. Comparing across individual domain scores, we see a similar trend of greater increases achieved with higher participation. In particular, MU, HU and RU groups together showed significance in score increases across all domains, gaining particularly on Composure (23.4% increase), Vision (19.9% increase), and Health (15.1% increase).

Table 2 summarizes domain-level results achieved for the full cohort that participated in re-measurement, alongside results limited to groups MU, HU and RU. Statistical significance is indicated for each factor. A visual summary is presented in Graph 2.

Comparing gender across the full cohort, females showed a 23.2% relatively larger increase in Composure improvement than males (p-value = <0.05), as well as a 9.1% greater increase in Tenacity (p-value = <0.05), and a 20.2% greater increase in Collaboration (p-value = <0.05). This follows from previous results showing that females improved more than males on average.

Health factor change. The PR6 Health domain items assess aspects, including overall perceptions of health, sleep quality, exercise frequency, and adherence to healthy nutrition patterns (adherence to a diet low in sugar and high in whole foods). These aspects were investigated for significance across the full cohort and the MU, HU and RU cohorts.

Results for the full cohort showed that, even though there were improvements across all aspects, the one aspect with statistical significance was improvement in healthy nutrition adherence. Confining data to MU, HU, and RU groups showed

Table 2

Domain Score Improvement

Domain	PR6	PR6-R	Improvement	P-value
Improvement across full cohort, *N*=245				
PR6	0.68823	0.74512	8.3%	< 0.001
Vision	0.6903	0.7612	10.3%	< 0.001
Composure	0.6255	0.7184	14.9%	< 0.001
Reasoning	0.7143	0.773	8.2%	0.001
Tenacity	0.7883	0.8337	5.8%	0.005
Collaboration	0.6556	0.676	3.1%	0.262
Health	0.6258	0.6801	8.7%	0.007
Improvement for MU, HU and RU, *n*=114				
PR6	0.6731	0.7784	15.6%	< 0.001
Vision	0.6678	0.8004	19.9%	< 0.001
Composure	0.5998	0.7401	23.4%	< 0.001
Reasoning	0.693	0.7971	15.0%	< 0.001
Tenacity	0.7763	0.8596	10.7%	0.001
Collaboration	0.636	0.6985	9.8%	0.02
Health	0.648	0.7456	15.1%	< 0.001

Note. PR6 = Predictive 6 Factor Resilience Scale; MU = moderate usage; HU = high usage; RU = recommended usage.

Table 3

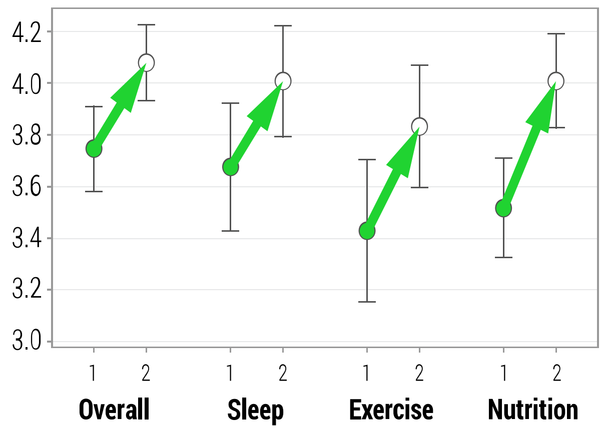
Health Factor Improvement

Domain	1	2	Improvement	P-value
Overall	0.6864	0.769725	12.1%	< 0.05
Sleep	0.66875	0.75225	12.5%	< 0.05
Exercise	0.6075	0.70825	16.6%	< 0.05
Nutrition	0.629375	0.7522	19.5%	< 0.001

Note. Overall = general perception of health; 1 = first measurement; 2 = second measurement.

Graph 3

Health Factor Change for MU, HU and RU Combined



Note. Individual standard deviations used to calculate intervals. Overall = general perception of health; 1 = first measurement; 2 = second measurement.

statistically significant improvements across all fields. This includes a 12.5% relative improvement in sleep quality (*p*-value = <0.05), a 16.6% relative improvement in exercise frequency (*p*-value = <0.05), a 19.5% relative improvement in healthy nutrition adherence (*p*-value = <0.001), contributing to a 12.1% relative improvement in perception of overall health (*p*-value = <0.05). These values are summarized in Table 3, with an interval plot mapping improvement for this cohort in Graph 3.

Gender analysis across both the full cohort and limited cohort of MU, HU and RU only found no statistically significant differences in health aspect improvements.

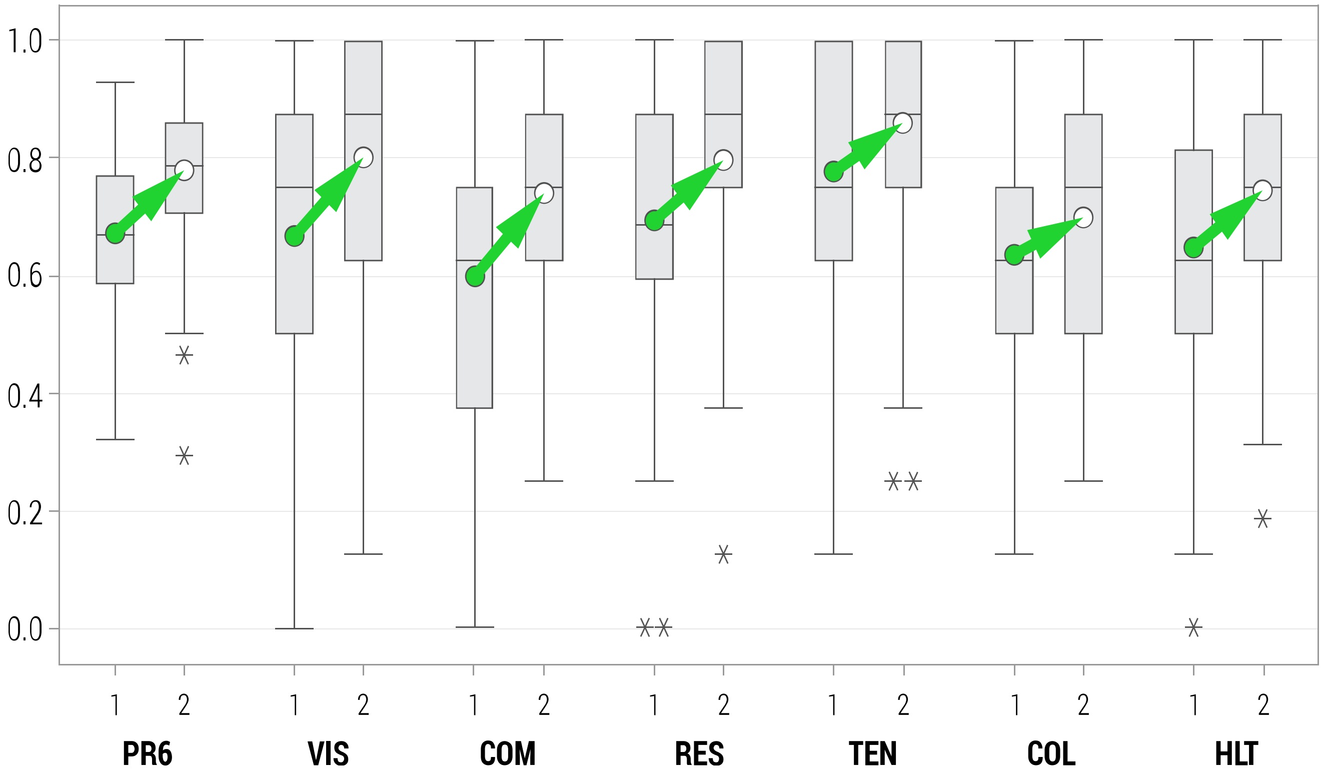
Regression Analysis

Predictors of resilience improvement was investigated through regression analysis across variables. Usage provided a statistically significant positive relationship to improvement in post-PR6 measurement (*R*-sq = 11.55%; *p*-value = <0.001). Further, starting PR6 score provided an unexpected predictor of resilience improvement, displaying an inverse relationship to improvement in resilience scores (*R*-sq = 15.12%; *p*-value = <0.001).

Multiple regression combining usage ratio and starting PR6 scores provided the strongest prediction of improvement, showing *R*-sq = 24.52% (*p*-value = <0.001). Further improvement in multiple regression *R*-sq of starting PR6 and usage ratio was possible through removal of NU and LU, providing an *R*-sq of 35.97%. Controlling by gender or removal of C4 did not yield any further improvement in prediction model accuracy.

Graph 2

Change in Domain Scores for MU, HU and RU Combined



Note. PR6 = Predictive 6 Factor Resilience Scale; 1 = first PR6 assessment; 2 = second PR6 assessment; VIS = Vision; COM = Composure; RES = Reasoning, TEN = Tenacity; COL = Collaboration; HLT = Health. Green arrows show larger change.

Individual domain starting scores were investigated for predictive properties regarding overall improvement. Multiple regression combining Reasoning starting score and Usage ratio provided a slightly higher *R*-sq (25.7% compared to 24.52% for PR6 multiple regression) for the overall prediction in improvement; however, a lower *R*-sq(pred) = 13.5% value indicates potential over-fit of this model to this dataset. The overall PR6 score consisting of all domains provide a more robust assessment tool that allows for greater generalizability across various cohorts.

Discussion

Results support the hypothesis that completion of more microtasks facilitated greater improvement in resilience and long-lasting behavioral change. Results also support a conclusion that Driven provides a valid pathway to enhance resilience capacity through a digital virtual coaching format using microtasks as a daily intervention approach. The NU and LU groups served as control groups for comparison, showing no significant change in resilience compared to the higher usage groups (MU, HU and RU). Within these usage groups, it was evident that higher usage predicted greater improvement in resilience capacity.

Regarding the mechanistic functioning of microtasks, analogous functioning has been found elsewhere in human physiology, for example, the finding that the high-intensity interval training (HIIT), which involves short bursts of physical exercise, has greater fat-burning capabilities than endurance training (Astorino & Schubert, 2014), and results in an increased metabolic rate for 24 hours after training (Treuth, Hunter, & Williams, 1996). Given the similarities in extended neural change following short bursts of learning, perhaps a way to think of this is that the microtask concept delivered through Driven is like HIIT for the brain.

The PR6 resilience psychometric showed strong internal consistency with both pre- and post-intervention assessments, supporting its use as a resilience diagnostic tool. This follows our previous validation results within organizational use (Rossouw et al, 2017). Improvements in domain scores showed Driven had particular strength in helping individuals improve stress management, gain a sense of purpose, and improve various physiological health aspects. Within the Health domain, we noted improvements in exercise frequency,

While the hypothesis of increased completion of microtasks would lead to an increase in resilience is shown to be valid, this study revealed an unexpected relationship between initial PR6 starting score and subsequent improvement. Indeed, we see that receiving a lower initial score predicts a greater level of participation and subsequent improvement.

This finding is significant, as it indicates that those in most need of resilience improvement are indeed the ones that participate the most in the program, and therefore improve the most. In effect, Driven helps those who need it most. This may stem from an "awareness effect," as each participant received a resilience report that indicated their current level of resilience. Once aware of their status of being below employee benchmarks, this may then spur interest within the individual to persist with the program and improve.

We hypothesize that these individuals may already be aware that their resilience is not at a preferred level, and the receipt of a report then triggers an initiative to improve. This effect, combined with instant access to a relevant training program (in this case, Driven) that provides a methodology to build resilience, appears to presents the right opportunity at the right time to lead to completion persistence and eventual lasting improvement.

Capitalizing on this effect can yield significant improvements in population health through broader applications in government, large organizations and insurance formats to reach wider audiences to providing help to those who need it. As a preventative approach to mental and physical health, Driven demonstrates a scalable intervention that may be applied to broad effect.

Gender differences. Higher stigma in males appears to start in early life (Chandra & Minkovitz, 2006), carry through as students (Eisenberg, Downs, Golberstein, & Zivin, 2006), and persist into adulthood (Corrigan & Watson, 2007). This phenomenon may influence studies that recruit volunteers for intervention research in mental health, skewing results toward that experienced by females which appear naturally more interested in engaging with and implementing new psychological strategies.

Results found in this study noted that, indeed, females improved more than males while using the course. However, participation and usage rates between males and females did not differ significantly. Thus, we note as a strength of this cohort broader male participation to provide insight into organization-provided tools relating to mental health. Here it may well be the application of a novel and fully confidential digital tool that enables males to increase self-disclosure, which has long been indicated as a strength of digital interventions (Weisband & Kiesler, 1996).

Limitations. The only psychometric test used in this review was the PR6, while additional testing in future would provide additional insight into impact on depression, stress, anxiety, and other mental health disorders. Mitigating this limitation is extensive existing research that links resilience as a valid strategy to manage these mental disorders (Edward, 2005; Masten et al., 2009; Rutter, 1985; Stoffel & Cain, 2018). Conducting randomized controlled trials that include broader psychometric assessments is a potential next step to continue validation of the program an investigate applicability as a digital intervention for common psychological disorders.

Real-world generalizability. In the views of the authors, these results are significant as they include a cohort that did not participate out of explicit interest to be part of research, but instead shows a real-world application within organizations interested in improving the resilience of employees. This means that participants were not encumbered by any potential perceptual influences or performance anxiety due to research oversight, but rather is subjected only to the influences that can be expected by the default application of this program within organizations. We believe this research to therefore show results that can be more widely replicated as a result.

Furthermore, as a longitudinal study that includes pre- and post-assessments of an intervention that lasted over 6 months, we see potential for sustained improvements that can lead to long-term benefits for employees, employers, and in personal and clinical settings. The authors note that comparable research in the field of digital interventions (particularly chatbots) tend to be shorter in nature, and therefore requires more longitudinal research to validate results. We therefore see the length of this study as a strength to confirm that the Driven resilience program can indeed assist in improving resilience over a longer timeframe, potentially mitigating or preventing the formation of depression, anxiety or stress through improvements across the six resilience domains.

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