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La relation entre le stress et l'utilisation du téléphone intelligent en marchant

par

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Résumé

Plusieurs études ont examiné l'utilisation du téléphone intelligent en déplacement et ses effets néfastes sur l'attention et la performance. Cependant, peu d'études se sont penchées sur la relation entre le stress et l'utilisation du téléphone en marchant. Ce mémoire vise à clarifier comment le stress influence notre propension à texter en marchant, comment cette-dernière influence le stress, ainsi que l'impact du stress sur nos capacités multitâche dans ce contexte.

Un total de 80 participants a complété deux tâches en laboratoire (une tâche où l'utilisation du téléphone était optionnelle et une tâche où ils devaient texter en marchant) tout en marchant sur un tapis roulant. Simultanément, les participants devaient indiquer la direction vers laquelle un autre marcheur se dirigeait.

Les résultats suggèrent que le stress, autant psychologique que physiologique, prédit l'utilisation du téléphone en contexte de déplacement piétonnier : les participants rapportant plus de stress psychologique et éprouvant des fluctuations de cortisol utilisaient leur téléphone plus souvent durant la tâche libre. De plus, chez les femmes, un plus grand nombre d'utilisations du téléphone menait à une réduction du stress psychologique; chez les hommes, une plus longue utilisation menait à une augmentation de stress physiologique. Finalement, le stress physiologique était plus prononcé chez les participants ayant une performance modérée.

Ces résultats permettront d'identifier des recommandations pour minimiser les risques associés à la marche distraite; ils seront également utiles aux développeurs d'applications mobiles lors du développement d'applications plus sécuritaires et mieux adaptées aux besoins des utilisateurs. Les résultats de ce mémoire contribuent également à la littérature sur les effets du stress sur le multitâche et sur le stress et le téléphone intelligent.

Mots clés : Stress · Multitâche · Attention divisée · Téléphone intelligent · Mobilité

Table des matières

Liste des tableaux et des figures

Liste des figures

Chapitre 2

Liste des tableaux

Chapitre 2

Liste des abréviations

PSU	Problematic smartphone use
NPSU	Non-problematic smartphone use
UPT	Utilisation problématique du téléphone
UNPT	Utilisation non-problématique du téléphone

Avant-propos

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Introduction

Mise en contexte de l'étude

Le phénomène de texter en marchant devient de plus en plus courant dans les milieux urbains. Cette utilisation multitâche du téléphone intelligent n'est pas surprenante : par leur grande versatilité et leur ubiquité, ces-dernier invite ses usagers à s'en servir à tout moment et pendant qu'ils effectuent d'autres activités (Roberts et al., 2014; Soukup, 2015). Texter en marchant est cependant un comportement dangereux chez les piétons. Cette activité combine un manque d'attention à l'environnement avec une démarche ralentie, ce qui met l'individu à un plus grand risque de collisions et de blessures (Parr et al., 2014). Plusieurs études démontrent les dangers de texter en marchant. Les piétons distraits par leur téléphone prennent 18% plus de temps à traverser une intersection (Thompson et al., 2013), effectuent au moins un comportement dangereux en moyenne (e.g., ne regardent pas des deux côtés avant de traverser) (Thompson et al., 2013) et ont plus de chances d'être heurtés par des véhicules et de subir d'autres types d'accidents (Byington & Schwebel, 2013; Kim et al., 2017; Schwebel et al., 2012). Des études récentes menées au Tech3Lab ont démontré que, lorsque les individus textent en marchant, ils performent significativement moins bien dans l'identification de stimuli dans leur environnement que lorsqu'ils ne font que marcher (Courtemanche et al., 2019). De plus, la dépendance au téléphone intelligent semble être associée à une plus basse performance (Mourra et al., 2020).

L'utilisation du téléphone intelligent est également associée à une large variété de troubles physiques et psychologiques, tels que la mauvaise forme physique (Lepp et al., 2013), les troubles du sommeil et la cyberintimidation (Sansone & Sansone, 2013) et les troubles de stress et d'anxiété (Elhai et al., 2016; Vahedi & Saiphoo, 2018). La relation entre les téléphones intelligents et le stress et d'autant plus importante que les niveaux de stress chez les Américains ont atteint leur plus haut point dans la dernière décennie (Gallup, 2019). D'après l'American Psychological Association, les sources majeures de stress rapportées sont le travail, l'argent, les responsabilités familiales, la santé et l'état de la nation (American Psychological Association, 2016). Or, il s'agit, dans la plupart des cas, de domaines de la vie quotidienne également associés à l'utilisation des téléphones intelligents : on s'en sert maintenant pour le travail (Son & Chen, 2018), pour effectuer nos transactions commerciales et bancaires (Talukder et al., 2014), pour maintenir nos relations sociales (Wei & Lo, 2006) et pour gérer notre santé (Batista & Gaglani, 2013). Étant donnée l'infiltration des téléphones intelligents et du stress dans notre quotidien, l'étude de leur relation devient hautement importante lorsqu'il est question de mieux comprendre le phénomène de texter en marchant.

À notre connaissance, il n'existe présentement aucune littérature sur la relation entre le stress et l'utilisation du téléphone intelligent en marchant. Cependant, plusieurs études se sont penchées sur l'association entre l'utilisation générale des téléphones intelligents et le stress. La majorité de ces études sont centrées sur l'utilisation problématique du téléphone (UPT), soit des modes d'interaction avec le téléphone ayant les caractéristiques de la dépendance (Lopez-Fernandez et al., 2014). Lorsqu'il est question d'UPT, le stress et l'anxiété sont manifestement présents : l'UPT serait un moyen de gérer les émotions négatives causées par la pathologie (e.g., stress, anxiété, dépression) (Billieux et al., 2015; Kim et al., 2015) et, à la fois, une source de stress et d'anxiété additionnelle (Hawi & Samaha, 2017; Kim et al., 2015; Lee et al., 2014; Samaha & Hawi, 2016). Certains suggèrent donc que l'UPT serait liée au stress par une « voie du réconfort » (Billieux et al., 2015). Ainsi, elle engendrerait un cycle vicieux où stress et anxiété amènent la surutilisation et cette-dernière, à son tour, amène davantage de stress (Kim et al., 2015).

Cependant, le phénomène de texter en marchant n'est pas nécessairement lié à une utilisation problématique du téléphone intelligent ; sa relation avec le stress pourrait donc être distincte. La littérature sur l'utilisation non-problématique (i.e., l'utilisation du téléphone intelligent dépourvue d'aspects malsains ou de dépendance) (UNPT) et le stress est moins vaste, mais offre tout de même quelques pistes. Dans l'absence de dépendance au téléphone, ce dernier pourrait fonctionner comme un réconfortant contre l'anxiété sociale et comme un support social (Hunter et al., 2018; Igarashi et al., 2005; Panova & Lleras, 2016). Cependant, bien que cette stratégie fonctionne à court terme, elle peut toutefois aussi mener à davantage de stress si elle est utilisée en excès (Panova & Lleras, 2016). Contrairement à la « voie du réconfort », cette stratégie opèrerait dans l'absence de pathologie et aurait des effets positifs à court terme.

Texter en marchant est une activité courante mais hautement dangereuse (Byington & Schwebel, 2013; Kim et al., 2017; Parr et al., 2014; Thompson et al., 2013). Afin de mieux informer le public et mitiger les risques, il est important d'étudier ce phénomène en relation avec le stress, un trouble de plus en plus courant (American Psychological Association, 2016, 2018; Gallup, 2019). L'étude du stress en lien avec l'utilisation du téléphone peut nous aider à comprendre les mécanismes derrière l'utilisation du téléphone en marchant, ainsi que les effets potentiels de cette activité sur le bien-être psychologique et physique. Ce champ d'enquête permettra également de clarifier l'amplitude des risques et leur interaction avec un facteur psychologique et physiologique tel que le stress.

Questions de recherche

L'utilisation du téléphone intelligent, qu'elle soit problématique ou non, semble être associée au stress. L'évidence suggère que le stress peut déclencher l'utilisation du téléphone, mais aussi que l'utilisation du téléphone peut mener au stress (Billieux et al., 2015; Kim et al., 2015). Cependant, la grande majorité de la littérature sur le sujet est constituée d'études transversales, ce qui ne permet pas d'établir des liens de causalité. Aussi, il n'est pas clair si une telle relation existe dans le contexte de l'utilisation du téléphone en marchant. Finalement, très peu d'études se sont penchées sur le stress physiologique (Riedl, 2012; Hunter et al., 2018; Afifi et al., 2018), un élément important dans notre compréhension du stress avec des répercussions importantes sur la santé et le comportement.

La présente étude s'est penchée sur trois principales lacunes dans la littérature sur l'utilisation du téléphone intelligent et le stress. Trois questions de recherche ont été formulées à partir de ces lacunes :

1. Comment le stress, autant psychologique que physiologique, influence-t-il la propension à utiliser le téléphone intelligent en marchant?

2. Comment l'utilisation du téléphone en marchant influence-t-elle les niveaux subséquents de stress psychologique et physiologique?

3. Quel est l'impact du stress physiologique sur notre capacité à texter en marchant sans risques?

Afin de répondre à ces questions, nous recréons une situation de multitâche au téléphone en marchant en utilisant les méthodes de Courtemanche et al. (2019). Les participants marchent sur un tapis roulant placé devant un écran, sur lequel un personnage est projeté à des intervalles de 20 secondes. À chaque apparition du personnage, le participant doit regarder l'écran et indiquer si ce-dernier se dirige vers sa gauche ou vers sa droite. L'expérience est divisée en deux sections (i.e., tâches) avec des contraintes et demandes différentes. Afin d'examiner l'impact du stress sur la propension à utiliser son téléphone en marchant, nous donnons aux participants le choix de se servir de leur téléphone durant la première tâche. Afin d'évaluer l'impact de cette activité sur le stress, nous prenons des collectes de salive et une mesure de stress psychologique par questionnaire entre chaque tâche.

Objectifs et contributions potentielles

L'objectif de ce mémoire est de clarifier la relation entre l'utilisation multitâche du téléphone intelligent et le stress. On s'intéresse spécifiquement à l'impact du stress sur la tendance à utiliser les téléphones intelligents en marchant, ainsi qu'à l'impact de cette tendance sur le stress. En étudiant ces deux aspects de la relation, ce mémoire contribuera à éclaircir le manque dans la littérature par rapport à la direction de la causalité entre le stress et l'utilisation du téléphone intelligent. Une autre contribution de ce mémoire sera de clarifier la relation entre l'utilisation du téléphone intelligent et le stress physiologique, un sujet encore peu abordé dans la littérature. D'un point de vue pratique, ce mémoire permettra d'identifier des recommandations pour des campagnes de santé publique sur les dangers de l'utilisation du téléphone en marchant chez les piétons. De plus, les résultats présentés dans ce mémoire pourront contribuer au développement de pistes d'adaptation pour les technologies mobiles ; les développeurs sauront alors comment utiliser les effets du stress à l'avantage des utilisateurs et réduire ainsi les risques qui s'y associent.

Résumé de l'article

Le but de l'article est d'étudier les effets du stress, autant psychologique et physiologique, sur la propension des participants à utiliser leur téléphone en marchant, ainsi que les effets de texter en marchant sur les niveaux de stress subséquents. L'article visait également à étudier les effets du stress sur les capacités multitâche lorsqu'on texte en marchant. Une expérience intra-sujet a été réalisée en laboratoire afin de répondre à ces objectifs. Un total de 80 participants a effectué deux tâches distinctes alors qu'ils marchaient sur un tapis roulant. Au cours des deux tâches, les participants devaient indiquer dans quelle direction un autre marcheur se dirigeait. Dans une première tâche libre, les participants avaient le choix de se servir de leur téléphone personnel comme ils le désiraient. Lors d'une deuxième tâche contrôlée, ils devaient maintenir une conversation via messagerie texte avec un assistant de recherche situé dans une autre salle. Le stress a été mesuré par questionnaire et par collecte de salive avant et après chaque tâche. Les résultats de l'étude suggèrent que le stress psychologique prédit l'utilisation compulsive du téléphone. De plus, les variations de cortisol (i.e., les augmentations ou diminutions de cortisol durant la tâche) étaient aussi associées à plus d'utilisations. L'utilisation du téléphone en marchant était également liée à une réduction du stress psychologique subséquent chez les femmes, et une augmentation du stress physiologique subséquent chez les hommes. Nous n'avons observé aucun effet du stress physiologique mesuré avant la deuxième tâche sur la performance; cependant, nous remarquons une relation quadratique entre le cortisol et la performance, où les participants avec une performance moyenne avaient de plus hauts niveaux de cortisol.

Contribution

Un tableau a été élaboré afin de démontrer les contributions de l'étudiante à ce mémoire (Tableau 1). Le tableau 1 inclut la contribution de l'étudiante et de l'équipe de recherche sous forme de pourcentage pour chaque étape du projet de recherche.

Tableau 1.1 - Contribution de l'étudiante aux étapes du projet de recherche

Étape du projet	Contribution
Formulation des questions de recherche	Identifier les questions de recherche en rapport avec le sujet choisi, pouvant être répondues avec le matériel – 80% • Le reste de l'équipe de recherche, avec la collaboration de Sonia Lupien, co-auteure de l'article, a contribué à la formulation des questions de recherche
Revue de la littérature	Élaborer et rédiger la revue de littérature pour identifier les construits et théories observés dans les études antérieures sur l'utilisation des téléphones intelligents et le stress – 100%
Conception du design expérimental	Définir et proposer les outils de mesure à utiliser selon les construits et théories choisis – 85% • Le reste de l'équipe de recherche, avec la collaboration de Sonia Lupien, co-auteure de l'article, a contribué à la définition des outils de mesure utilisés Compléter la demande au CER et les demandes de modification de projet subséquentes – 100% Élaborer et rédiger le protocole de l'expérimentation – 100% Assurer la mise en fonction du tapis roulant et des logiciels E-Prime, Morae et Media Recorder – 80% • Emma Rucco, Louis-Félix La Roche-Morin et Élise Imbault, de l'équipe de recherche, ont contribué à l'installation, la préparation et aux tests du matériel dans la salle de collecte Préparer et organiser le matériel requis pour les collectes de salive – 100%
Recrutement des participants	Recruter et gérer les participants – 100% Administrer les compensations – 100% Élaborer et rédiger les questionnaires de recrutement – 100% Concevoir et assembler le cartable d'expérience pour le suivi des participants – 50%

	• Élise Imbault et Ariel Garand, de l'équipe de recherche du Tech3Lab, ont assuré l'assemblage et la mise à jour des cartables de suivi des participants
Collecte des données	Effectuer les collectes des données – 100% • L'étudiante a reçu le support de l'équipe des techniciens de recherche lors de chaque collecte Offrir du soutien technique aux assistants de recherche en cas de problème – 75% • L'étudiante a partagé cette responsabilité avec David Brieugne et Louis-Félix La Roche-Morin, de l'équipe de recherche du Tech3Lab
Extraction des données	Extraire et mettre en forme les données psychométriques – 100% Extraire, mettre en forme et analyser les données de cortisol salivaire – 75% • L'étudiante a reçu le support du laboratoire d'analyse du Centre d'Étude pour le Stress Humain pour l'extraction et l'analyse des échantillons de salive
Analyse des données	Effectuer les analyses statistiques de l'article – 90% • L'étudiante a reçu l'aide du statisticien de l'équipe de recherche
Rédaction	Contribution dans l'écriture de l'article du mémoire – 100%

Structure du mémoire

Les chapitres qui suivent décrivent l'entièreté des résultats du projet de recherche. Le chapitre 1 présente une revue de littérature au sujet de l'utilisation du téléphone intelligent et sa relation avec le stress. Ensuite, le chapitre 2 présente l'article décrivant l'étude qui a été effectuée, ainsi que les résultats de cette étude. Pour fins de publication éventuelle, ces deux chapitres sont rédigés en anglais. Le chapitre 3 offre une discussion approfondie sur les aboutissements de la revue de littérature et de l'article, ainsi que sur les limitations de l'étude et les futures directions de recherche.

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Chapitre 1: Revue de la littérature

1.1 Introduction

Since the introduction of the first popular smartphone by Apple in 2007, smartphones have become a ubiquitous and democratized technology. A recent report by the Pew Research Center (2019) shows that 81% of adults in the US possess a smartphone, and among young adults between 18 and 34 years old, as many as 95% report owning a smartphone. Over the past three years, however, age gaps have been closing and smartphone adoption has continued to grow in advanced and emerging economies alike. In fact, many young adults now report that they cannot envision their lives without their smartphone (Roberts et al., 2014). This could be due to the smartphone's wide variety of non-traditional phone activities that can be carried anywhere and at any time (Roberts et al., 2014; Soukup, 2015). It is this abundance of uses and functionalities that has turned smartphones into an important part of people's healthcare (Batista & Gaglani, 2013), interpersonal relationships (Wei & Lo, 2006), banking and commercial transactions (Talukder et al., 2014), entertainment (Mutchler et al., 2011), and work life (Son & Chen, 2018).

Increases in smartphone adoption are occurring at the same time than increases in self-reported stress in the US according to a 2018 report by the American Psychological Association (APA), as many as 74% of American adults said that they had experienced at least one symptom of stress in the past month, and 45% of reported lying awake at night due to stress. A recent Gallup poll (2019) showed that feelings of stress and worry in America have reached their highest point in a decade. Stress is a complex phenomenon and its sources are vast and interconnected: throughout the years, Americans cite work, money, family responsibilities, health, and state of the nation as the main stressors in their lives (American Psychological Association, 2016). Interestingly, the latest APA (2018) report on stress shows that half of young Americans aged 15 to 21 use social media to cope with stress, but that nearly two in five also report feeling worse as a result of social media use.

Both smartphones and stress are very present in Americans' lives and connect to different facets of their experiences: work, money, family, entertainment, health, and more. It is therefore critical to explore the relationship between smartphone use and stress. The insights derived from such an understanding may be useful in the crafting of policy and public health campaigns to help individuals mitigate risks. Moreover, smartphone and application developers would greatly benefit from information helping them to better adapt this technology to users' needs.

1.1.1 Aim and scope

The aim of this literature review is to provide an in-depth understanding of the relationship between smartphone use and stress. To achieve this, the focus will be on examining both psychological and physiological stress through the lens of problematic and non-problematic phone use. Because smartphones are often used in the context of multitasking, the relationship between stress and multitasking ability will also be examined.

1.1.2 Definitions

Stress and anxiety

Stress and anxiety are emotional and physical states that have a direct impact on our perceived quality of life. Although they are often used interchangeably, stress and anxiety refer to different psychological constructs.

Stress is a biological, behavioral, and psychological state that occurs when an organism must adapt to an environmental obstacle or threat (Baum, 1990; Giannakakis et al., 2017). In humans, stress can be differentiated into a physiological and a psychological component. Physiological stress refers to the secretion of hormones (in humans, cortisol) which prepare the organism for the "fight or flight" response (Schneiderman et al., 2005). Psychological stress, meanwhile, refers to the relationship between the person and the environment that is appraised by the person as taxing, exceeding her resources, or endangering her well-being (Lazarus and Folkman, 1984). Psychological stress also urges for action, as its resulting emotional state motivates the individual to find appropriate coping strategies (Baum, 1990). Thus, whether physiological or psychological, the stress response is stimulus-oriented, adaptive, and considered harmless to the health of the organism. However, in situations where threat is persistent, the stress response can become chronic and damage psychological and somatic health, resulting in troubles such as substance abuse, schizophrenia, heart disease, and infectious diseases (Schneiderman et al., 2005).

Stress in relation to technology is commonly referred to as *technostress*. Originally coined by psychologist Craig Brod in 1984, technostress referred to an inability to cope with the constant changes brought upon by technology (Ayyagari et al., 2011; Brod, 1984). The definition of technostress was later broadened by Weil and Rosen (1997) as "any impact on attitudes, thoughts, behaviors or psychology caused directly or indirectly by technology." Today, technostress is more commonly defined as "an IT user's experience of stress when using technologies" (Ragu-Nathan et al., 2008) and is characterized by higher levels of stress hormones, psychological activation, poor concentration, and irritability. For instance, Tams et al. (2015) and Tams (2011) observed that frequent interruptions in the form of instant-message notifications can increase mental workload in work environments, eventually leading to self-reported stress. Similarly, Riedl et al. (2012) showed that system breakdown in the context of human-computer interaction significantly increased users' cortisol levels. Some research has examined technostress in relation to smartphones, establishing that smartphones may also create significant stress in their users (e.g., Hsiao et al., 2017; Lee et al., 2016; Lee et al., 2016).

Anxiety, on the other hand, is characterized by thoughts of worry or fear about the future (Giannakakis et al., 2017). While the stress response is usually stimulus-oriented and therefore temporary, anxiety is diffuse, persistent, and often without an identifiable cause (Helgoe et al., 2005). In spite of these differences, both anxiety and stress generally manifest through the same type of physiological responses: rapid heartbeat, sweaty palms, stomach cramps, and the secretion of stress hormones, such as cortisol (Giannakakis et al., 2017; Lenze et al., 2011). Like stress, anxiety can become harmful when it is frequent and its intensity disproportionate to threat levels. In those cases, it may lead to a variety of anxiety disorders (Parekh, 2017), which in turn can result in higher morbidity and mortality (Albert et al., 2005; Kawachi, 1994).

Because of these similarities between the expression and outcomes of stress and anxiety, we chose to consider both constructs in our assessment of smartphone use and its relationship with stress.

Problematic smartphone use

Problematic smartphone use (also called “problematic cell phone use” or “mobile phone abuse or addiction”) is a pattern of smartphone use that has the characteristics of addiction (Lopez-Fernandez et al., 2014). Problematic smartphone use (PSU) occurs when the use of smartphones becomes excessive or uncontrolled and leads to negative psychological, physical, and social outcomes (Billieux, 2012). Some of these outcomes may be sleep disturbances (Sansone & Sansone, 2013), dangerous driving (Sun & Jia, 2016), poor physical fitness (Lepp et al., 2013) or dependence symptoms such as excessive use, interference with personal life, or gradual increases in use to obtain the same satisfaction (Choliz, 2010). Aside from these negatives outcomes, PSU is comorbid with other types of psychopathology, such as anxiety, depression, and stress (Babadi-Akashe et al., 2014; Elhai et al., 2017; Wang et al., 2015).

In 2015, the World Health Organization recognized excessive use of smartphones as a public health concern. However, the fifth and latest edition of the Diagnostic and Statistical Manual (DSM-5) has not acknowledged PSU as an addiction. To date, the DSM-5 only includes substance addictions in the “Substance-Related and Addictive Disorders,” because they activate the brain’s reward circuitry when taken in excess. However, certain types of compulsive behaviors are known to display some of the characteristics of addiction in the absence of psychoactive substances (e.g., compulsive buying, stealing, sexual behavior, Internet use, smartphone use, etc.) (Choliz, 2010; Holden, 2001; Potenza, 2014). Yet these disorders remain classified as “impulse disorders,” as the American Psychiatric Association (2013) considers that there is still insufficient evidence to establish their diagnostic criteria as addiction disorders. For the moment, compulsive gambling is the only behavioral addiction that has been officially recognized as a "Substance-Related and Addictive Disorder" by the DSM-5. While PSU remains unrecognized as an addiction disorder, most researchers and clinicians on the topic agree that it is a true condition affecting patients' lives (Gutierrez et al., 2016).

For the purposes of this review, we have distinguished between problematic and non-problematic smartphone use (PSU and NPSU, respectively). This distinction was deemed necessary when assessing the variety of methods used to measure smartphone use in the literature. While some focus specifically on problematic use (e.g., addiction, dependence, excessive use), others record smartphone use on a continuum (e.g., number of daily text messages or calls, minutes or hours of daily usage). We believe that these methodological differences are important to the interpretation of results. While the former type represents extreme and unhealthy usage patterns, the latter are merely objective measures of phone usage. Although attempts have been made to propose diagnostic criteria for smartphone addiction based on usage variables (Lin et al., 2015), no such criteria have yet been accepted as indicators of PSU or smartphone addiction. Thus, studies that utilized measures of smartphone use devoid of "problematic" use patterns and based purely on behavior (e.g., minutes of use, number of text messages) have been considered as studies of NPSU.

1.2 Smartphone use and psychological stress

The vast majority of the research on smartphone use and stress is focused on problematic smartphone use (PSU). A review by Elhai et al. (2016) reported a low-to-moderate relationship between anxiety or stress and PSU. More recently, a meta-analysis of 37 studies conducted by Vahedi and Saiphoo (2018) also found a low-to-moderate relationship between stress and anxiety and (problematic or non-problematic) smartphone use. In spite of these results, some questions remain. For instance, because most of this research has been cross-sectional, it is still unclear whether smartphone use (problematic or not) causes stress and anxiety, or vice-versa (Vahedi & Saiphoo, 2018). In addition, very little research has been conducted on non-problematic smartphone use (NPSU) and its relationship with stress and anxiety. The following sections will review the literature regarding psychological stress and anxiety in relation to both PSU and NPSU.

1.2.1 Problematic smartphone use

Most of the research concerning problematic smartphone use (PSU) and stress and anxiety focuses on psychopathology (e.g., depression, stress and anxiety disorders) and its effects on PSU. A review of this literature suggests that psychopathology is a risk factor of PSU and that PSU, in turn, can lead to psychopathology.

For instance, Billieux et al. (2015) have proposed the "reassurance pathway" model where PSU functions as a strategy for avoiding the negative emotions created by psychopathology. This model is based on evidence that individuals suffering from chronic stress, anxiety, or depression use technology to relieve their negative emotions. For example, a cross-sectional study conducted by Kim et al. (2015) using national data from the United States found that those suffering from depression were more likely to engage in PSU in order to alleviate negative emotional states. Similarly, a study by Lu et al. (2011) found that anxiety related to relationship maintenance in Japanese adolescents was negatively correlated to text-message dependency, suggesting that adolescents use text-messaging to reduce relationship anxiety. In a sample of Chinese college students, Han et al. (2017) found that shyness was positively correlated with attachment anxiety, which in turn predicted mobile phone addiction. This suggests that shy individuals experience anxiety over being lonely and using their smartphone is a way of alleviating this loneliness. Several other studies have reported findings where anxiety and stress emerge as predictors of PSU or smartphone addiction (e.g. Boumosleh & Jaalouk, 2017; Cho et al., 2017; Kuang-Tsan & Fu-Yuan, 2017). In a recent study by Elhai and Contractor (2018), higher levels of rumination and cognitive reappraisal as emotion-regulation strategies were associated with PSU. Thus, PSU may also function as a strategy to cope with the negative emotional states caused by psychopathology. To date, however, no studies have been carried out to determine whether this strategy is effective.

Some research shows that this type of reassurance-seeking is a feature and a maintenance factor of stress and anxiety disorders (Cougle et al., 2011), as well as a risk factor of addiction (Nikmanesh, Kazemi et al., 2014). In their aforementioned study, Kim et al. (2015) suggest a "poor-get-poorer" perspective, in which mobile phone use as an emotional antidote is unhealthy and may lead to further dysfunction. It is therefore possible that the pathway of psychopathology leading to PSU is a vicious cycle. Some research does suggest that PSU itself leads to greater anxiety and stress (Hawi & Samaha, 2017; Lee et al., 2014; Samaha & Hawi, 2016; Thomée et al., 2011), though most of these studies are cross-sectional and the direction of this causality is yet to be determined.

When examining the literature through the lens of PSU, it is clear that a relationship exists between PSU and stress, although further research is needed to confirm causality. Almost all studies concerned with PSU and smartphone addiction report relationships with psychopathology and other negative outcomes, such as sleep disturbances and cyberbullying (Sansone & Sansone, 2013). These results are unsurprising considering that PSU has been reported to have dependence-like symptoms (Choliz, 2010).

1.2.2 Non-problematic smartphone use

To our knowledge, few studies have examined the effects of stress or anxiety on non-problematic smartphone use (i.e., smartphone use without the characteristics of addiction) (NPSU). Some literature does exist on the effects of NPSU on stress and anxiety, but results are mixed: while some report that NPSU reduces stress, others suggest it increases it.

For instance, there is evidence that NPSU can reduce anxiety and stress in the absence of psychopathology. In this regard, Hunter et al. (2018) propose a "social blanket" model where smartphones act as a buffer against social anxiety. Their experiment consisted of exposing participants with and without access to their phones to a social exclusion stressor. Results showed that participants in the phone-present conditions (where phone use was either discouraged or encouraged) reported lower levels of social exclusion than those in the no-phone condition. Moreover, participants whose phone was present experienced a significantly greater decline in salivary alpha amylase (a physiological stress marker) than participants in the no-phone condition. Thus, the mere presence of the participant's smartphone acted as a buffer against the psychological and physiological effects of an acute stressor. Other studies have shown that NPSU can increase social support (Igarashi et al., 2005; Rettie, 2008) and reduce relational anxiety (Jin & Peña, 2010). Panova and Lleras (2016) posit that in the short-term, mobile phone use for the purposes of escapism (i.e., *avoidance coping*) can be moderately effective. Unlike the "reassurance pathway" discussed previously (Billieux et al., 2015), avoidance coping need not be fueled by psychopathology, but may simply occur in response to acute stressors and in the absence of PSU. In fact, Toda et al. (2014) found that mobile phone dependence was not associated with this avoidance coping. However, the effects of avoidance coping on stress may be different in the long-term (Panova & Lleras, 2016).

In fact, an abundance of studies suggest that NPSU, as well, is associated with increased stress and anxiety. In 2005, Chesley (2005) used correlational data to report that the persistent use of communication devices such as cellphones increased distress and decreased satisfaction in families. Thomée al. (2007) found that the use of mobile phones was associated with a higher risk of reporting stress and symptoms of depression, and that daily number of text messages was positively correlated with prolonged stress. Other, more recent studies report similar results: Murdock (2013) found that students who were frequent texters were also more vulnerable to interpersonal stress, and Lepp et al. (2014) found that frequency of cell phone use was positively correlated with anxiety. Thus, even in cases where smartphone use is non-problematic, it has nonetheless been associated with higher levels of psychological stress or anxiety.

An important factor to consider is the distinction between acute and chronic (i.e., short-term and long-term) stress. As suggested by Panova and Lleras (2016), smartphone use for the purposes of avoidance coping may reduce stress and anxiety in the short-term. However, an over-reliance on this type of behavior may lead to increased levels of stress and anxiety in the long-term, a theory that seems supported by the literature linking both NPSU and PSU to high levels of stress and anxiety (e.g., Elhai et al., 2016; Vahedi & Saiphoo, 2018).

There is evidence to suggest that a relationship exists between PSU and various forms of psychopathology, among which stress and anxiety. The "reassurance pathway" (Billieux et al., 2015) posits that individuals suffering from psychopathology turn to their smartphones to relieve negative affect. This type of reassurance-seeking behavior, in turn, could lead to increases in stress and anxiety. In the case of NPSU, evidence suggests that smartphones can be used for avoidance coping purposes when individuals wish to increase their social support or reduce social anxiety. Unlike the reassurance pathway, this coping strategy is not connected to PSU nor fueled by psychopathology, but rather by acute stressors. However, if used exceedingly, avoidance coping may still lead to PSU and to increases in stress and anxiety.

The relationship between smartphone use and stress and anxiety manifests in similar ways whether smartphone use is problematic or not. It is important to keep in mind that almost all of this research has been cross-sectional and further investigation will be needed to determine causality.

1.3 Smartphone use and physiological stress

The vast majority of the literature examining the relationship between PSU or NPSU and stress has focused on psychological stress, while little attention has been directed to physiological stress (Afifi et al., 2018). This may be due to the cross-sectional nature of most studies and to the methodological and logistical challenges associated with physiological data collection. However, we suggest that an in-depth understanding of smartphone use and its relationship to stress ought to include physiological stress, as biology is an important determinant of health and behavior.

A number of studies have examined technostress in relation to information and communication technologies (ICT) using a biological approach. Riedl (2012) conducted a literature review of 15 studies on biological technostress associated with ICT. A major finding was that human interaction with computers often results in increases in physiological stress markers (e.g., skin conductance, heart rate, blood pressure, and secretion of stress hormones) which can have potential negative effects on health. Another study reported that system breakdowns led to a significant increase in computer users' cortisol levels (Riedl et al., 2012). Other, more recent studies have reported increases in cortisol levels following video game use (Brom et al., 2014; Gentile et al., 2017) and social media use (Morin-Major et al., 2015).

In regard to mobile phones, the first studies examining their use in relation to stress were interested in the effects of electromagnetic frequencies (EMF) emitted by mobile phones on hormonal stress markers (e.g., Braune et al., 2002; de Seze et al., 1998; Mann et al., 1998). A review on this subject reported that there is insufficient evidence for a relationship between EMF emitted by cellphones and any health outcomes (Röösli, 2010). More recently, the concern has shifted to the short wavelength light (i.e., blue light) emitted by the LED screens on smartphones and other devices and on the effects it can have on sleep quality and stress hormone secretion. Exposure to blue light during night-time has been associated with negative effects on cardiovascular and metabolic functions, as well as with increases in cortisol secretion and disturbances in melatonin secretion (for a review, see Cho et al., 2015).

To our knowledge, however, no studies have examined physiological stress markers in relation to PSU. Regarding NPSU, Hunter et al. (2018) showed that the mere presence of the participant's smartphone during social stressor exposure was related to a significantly greater decrease in alpha amylase. This suggests that when used for avoidance coping purposes, smartphones may help decrease the concentration of stress hormones in users. However, to our knowledge, this study is the only one that has examined the effect of such avoidance coping on physiological stress. In a cross-sectional study involving families, Afifi et al. (2018) reported that adolescents with greater phone use experienced a significantly greater rise in cortisol levels in the morning (i.e., cortisol awakening response, CAR), while fathers with the same type of use experienced a lower CAR. Studies have shown that a too-great or too-small CAR is associated with mental health issues (Fries et al., 2009). These results suggest that NPSU could have a negative impact on physiological stress in the long-term, but further experimental research will need to be carried before stronger conclusions can be drawn.

In summary, research on smartphone use and physiological stress remains very limited. Previous research on information and communication technologies has shown that human-computer interactions often lead to increases in physiological stress markers, although it is unclear whether this relationship extends to smartphones. Research on smartphone use in particular indicates that exposure to blue light emitted by smartphone screens at night may have an impact on physiological stress markers and sleep quality. Very little research has been conducted on PSU or NPSU and their relationship with physiological stress, however. Future cross-sectional studies could include this type of data to establish relationships between psychological and physiological stress depending on smartphone use. In addition, experiments can be devised where physiological stress is used as a dependent or independent variable.

1.4 Task-switching

Texting while walking involves multitasking. More specifically, it involves *task-switching*. A person who texts while she walks must constantly switch her attention between her phone screen and her environment. Task-switching is defined as the ability to switch one's attention from an initially important feature of a stimulus to another that subsequently conveys information about where to respond correctly, or to obtain a reward (Butts et al., 2013). As such, task-switching is a phenomenon which demands great cognitive flexibility. In a typical task-switching experiment, a participant performs a given task on each trial. The task may change from one trial to another (task-switch) or remain the same (repetition). Performance in task-switching is calculated by comparing a participant's performance during repetitions to their performance during switches (Kiesel et al., 2010). For example, the experimenter might ask a participant to indicate whether the number that appears on a screen is even or odd (task A), or below or above 5 (task B). At irregular intervals, a sound cue would indicate a task change (i.e., from A to B or from B to A) (Altmann & Gray, 2008).

When a person alternates between tasks in such a way, her performance depends on her ability to maintain a mental representation of each task (Altmann & Gray, 2008). This representation is called a task-set (Monsell, 1996). Thus, when the participant switches from task A to task B, she must first inhibit the A task-set and then activate the B task-set. This process is called task-set reconfiguration (Rogers & Monsell, 1995). There is a cognitive cost associated with task-set reconfiguration, however. Hodgetts and Jones (2006) showed this in an experiment where participants had to solve a complex puzzle in a series of planned moves. While performing this task, they were interrupted irregularly 8 trials out of 25. Results showed that the time taken to perform the next move on the puzzle increased after each interruption. In addition, this cost increased with the complexity and the duration of the interruption (Hodgetts & Jones, 2006).

Allport et al. (1994) attribute task-switching costs to the proactive interference of the previous task over the present task. Thus, when a participant switches from Task A to Task B, the A task-set remains activated and interferes momentarily with the demands of task B. This interference is called *attentional inertia* (Allport et al., 1994). Longman et al. (2014) showed this phenomenon in a task-switching experiment where digits appeared simultaneously at 3 different locations. Before the display, a cue indicated which of three different tasks had to be performed. Each task was consistently associated to a location. Results showed that when task-switching, the participants' attention was attracted to the previously relevant location more than to the other irrelevant locations, suggesting that the switch costs are more associated with the carry-over effects of the previous task rather than distractibility (Longman et al., 2014). While some studies have demonstrated ways in which task-switching costs can be reduced (Meiran, 1996; Monsell & Mizon, 2006), it is generally understood that they can never be fully eliminated (Longman et al., 2014; Nieuwenhuis & Monsell, 2002).

Courtemanche et al. (2019) used a task-switching paradigm to study the attentional and behavioral effects of using one's smartphone while walking. Their study consisted of two intra-participant blocks: walking on a treadmill and walking on a treadmill while chatting via text message. Every 20 seconds, a moving figure of a walker appeared on a screen across from the participant, preceded by a sound cue. Participants had to indicate if the walker figure headed to their left or their right. The results of Courtemanche et al. (2019)'s experiment showed that the probability of responding correctly was significantly lower when participants texted while walking. Also, electroencephalographic wave analysis showed that task-switch costs were higher when participants switched from texting to identifying the walker's direction than vice-versa. According to the researchers, this is evidence that additional resources are required to inhibit the task of texting in such a context, though the reasons for this remain unclear (Courtemanche et al., 2019).

Task-switching is thus a useful paradigm through which we may understand the cognitive demands associated with texting while walking. As texting while walking involves constant interruptions – i.e., switching from texting to navigating the environment, and vice-versa—we can infer that there are cognitive costs associated. The literature on task-switching suggests that task-set interference is the main culprit of such costs, and Courtemanche et al. (2019) showed that such interference is present in individuals who text while walking and simultaneously have to pay attention to their environment. Given that smartphone use has been associated with stress, however, it is important to consider the potential effects that stress may have on an individual's performance in such a demanding cognitive task.

1.4.1 Effects of stress on task-switching

Stress is a known modulator of cognitive processes. Studies that examined chronic stress have found strong cognitive impairment in task-switching (Liston et al., 2009; Sokka et al., 2017), which is consistent with the evidence that chronic stress causes long-term degradation of health (Schneiderman et al., 2005). In regard to acute stress, the evidence is mixed. Acute stress is known to affect different areas of cognition, such as long-term memory (Dominique et al., 2000), working memory (Lupien et al., 1999) and cognitive control (Goldfarb et al., 2017). However, the effects of acute stress on general cognition remain unclear; while stress sometimes appears to enhance certain cognitive functions, it also seems to impair others (Shields et al., 2016). Indeed, evidence suggests that stress may have diverse effects on different aspects of cognition (Mendl, 1999; Shields et al., 2016).

One of the first theories proposed for how stress affects cognitive function was the inverted U theory, originally developed by Yerkes and Dodson (1908) in the study of learning in mice. They found that the number of trials required to learn a task was reduced significantly when mice were shocked with high-intensity electricity. Further findings suggested that optimal performance occurred with moderate levels of arousal, and that too little or too much arousal would hinder performance (Kofman et al., 2006). For instance, in a serial enumeration task, both high and low doses of caffeine were found to hinder performance (Watters et al., 1997). In her review, Sandi (2013) concluded that moderate stress levels tend to facilitate cognition in tasks that do not generate great cognitive load. However, while Yerkes and Dodson (1908)'s inverted U theory seems intuitive, there is evidence that high levels of stress can also facilitate certain types of cognitive processes (Sandi, 2013; Shields et al., 2016).

A more recent theory suggests that the effect of stress on cognitive function is switching cognition from top-down processes to bottom-up, automatic processes (Gagnon & Wagner, 2016; Vogel, Fernández et al., 2016). According to this theory, stress impairs higher-order cognitive functioning in order to facilitate well-learned habits and routines that can generate faster responses (Schwabe & Wolf, 2013). Studies by Broadbent (1971) have shown that when exposed to loud noises, individuals were faster at performing simple or well-rehearsed tasks, but experienced significant impairment in more complex tasks. This theory would predict that stress increases task-switching costs and would thus make the process of task-set reconfiguration more effortful. The literature suggesting that stress impairs cognitive inhibition (Sänger et al., 2014), working memory (Oei et al., 2006) and cognitive flexibility (Alexander et al., 2007) is congruent with this theory.

Few studies have examined the effects of stress on task-switching specifically. Most of them report that stress impairs performance (Goldfarb et al., 2017; Liston et al., 2009; Orem et al., 2008; Plessow, Kiesel et al., 2012). However, some studies have found that stress enhances dual-task performance (Beste et al., 2013), even in task-switching trials (Lin et al., 2018).

In summary, although stress is known to be an important modulator of high order cognitive processes, the precise effects that it has dual-task performance are still unclear. To our knowledge, no studies have yet examined the effects that smartphone-generated stress can have on cognitive performance when texting while walking.

1.5 Conclusion

The aim of this literature review was to provide an in-depth understanding of the relationship between smartphone use and stress, and between stress and task-switching. To achieve this, we first examined smartphone use in relation to psychological and physiological stress through the lens of problematic and non-problematic phone use. Finally, we surveyed the literature on stress and its effect on task-switching trials.

Studies examining the link between stress and smartphone use can be divided into those focusing on problematic smartphone use (PSU) and those that measure smartphone use without a maladaptive aspect (NPSU). Almost all of the literature regarding smartphone use and stress is focused exclusively on psychological stress. Studies on PSU and NPSU have established a relationship between smartphone use and stress and anxiety. Those focusing on PSU report that pathological stress, anxiety, or depression are often precursors of PSU (e.g., Boumosleh & Jaalouk, 2017; Cho et al., 2017; Kuang-Tsan & Fu-Yuan, 2017); smartphone use is thus perceived as a strategy to alleviate pathological emotion (Billieux et al., 2015). However, PSU is also reported to generate stress and anxiety (Hawi & Samaha, 2017; Lee et al., 2014; Samaha & Hawi, 2016; Thomée et al., 2011). In regard to NPSU, the literature also suggests that this type of smartphone use may be a way of coping with social stress. Although some report that this strategy can be effective (Hunter et al., 2018; Panova & Lleras, 2016), there is evidence to suggest that even NPSU can increase stress in the long-term (Thommée et al., 2007; Murdock, 2013; Lepp et al., 2014).

In regard to physiological stress, few studies have examined how smartphone use influences physiological stress markers. Some studies have addressed the relationship between computer use and its impact on physiological stress; the bulk of this evidence suggests that computer use can lead to increases in skin conductance, heart rate, and secretion of stress hormones (Riedl, 2012; Riedl et al., 2012). While some research has addressed the effects of night-time blue-light exposure on physiological stress markers and sleep quality (Cho et al., 2015), no research has, to our knowledge, reported on the effects of smartphone use (either problematic or non-problematic) on immediate physiological stress markers.

Multitasking with a smartphone is a highly-demanding cognitive task which tends to involve task-switching. There are cognitive costs associated with switching from one task (i.e., texting) to another (i.e, navigating one's environment) (Allport et al., 1994); these costs can translate into slower processing and may partly be the cause of the accidents associated with pedestrians who text while walking (Allport et al., 1994; Byington & Schwebel, 2013; Kim et al., 2017; Schwebel et al., 2012). Although it is well-known that stress has an effect on cognition, these effects remain unclear as they seem to vary across cognitive function, and the task being performed. While some have suggested that cognitive performance is best as moderate stress levels (Yerkes & Dodson, 1908), others propose that stress hinders high-level cognitive performance in favor of habit-based, quicker processes (Gagnon & Wagner, 2016; Vogel et al., 2016). Finally, studies examining the effects of stress on task-switching have found conflicting results (Goldfarb et al., 2017; Liston et al., 2009; Beste et al., 2013; Lin et al., 2018).

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Chapitre 2 : The relationship between stress and texting while walking

Abstract

Texting while walking (TWW) is a dangerous behavior. While several studies have examined the relationship between smartphone use and stress, to our knowledge no studies have yet investigated the relationship between stress and TWW. Thus, the objective of the present study was to describe this relationship by examining the effects of stress on TWW, the effects of TWW on subsequent stress, and the effects of stress on multitasking performance. A total of 80 participants completed two sequential tasks in a laboratory while they walked on a treadmill and responded to a biological motion stimulus imitating the movement of another pedestrian. In the unrestricted task, participants were given the choice to use their personal phones. In the controlled task, they carried a text conversation with a research assistant while they walked and responded to the stimulus. Stress was measured via questionnaire and saliva collection before and after each task. Results showed that greater psychological stress and cortisol variations predicted a greater number of phone uses during the unrestricted task. Phone uses during the unrestricted task were negatively correlated with concurrent psychological stress in women, and total time of phone use was positively correlated with subsequent cortisol levels in men. Stress measured before the controlled task had no effect on multitasking performance, but participants with moderate performance were those with the highest cortisol levels. Our results suggest that stress is a precursor to TWW, and that the effects of TWW on stress may be sex-dependent.

2.1 Introduction

Smartphones have become an integral part of our daily lives and their adoption continues to grow. It is predicted that by 2020, 3 billion people will own smartphones across the globe (Statista, 2019). Yet smartphones are way more than traditional telecommunication devices: they allow us to access the Internet and use online banking services, on-demand entertainment, social media, and much more, anywhere and at any time (Roberts et al., 2014). Given this versatility, it is unsurprising that smartphones encourage users to spend more time using their phones while other things (i.e., multitasking) (Soukup, 2015). One such type of multitasking is texting while walking (TWW).

Texting while walking is a dangerous behavior. It involves both a lack of attention to the environment and a slower walking pace, which puts individuals at a greater risk of collisions and injuries (Parr et al., 2014). A study reported that pedestrians who texted while walking took 18% longer to cross an intersection and performed at least one risky behavior on average compared to non-distracted pedestrians (Thompson et al., 2013). Other studies have shown that pedestrians who use their smartphones while walking are more likely to be hit by moving vehicles and suffer from other types of accidents (Byington & Schwebel, 2013; Kim et al., 2017; Schwebel et al., 2012). Moreover, as smartphone usage continues to increase, accidents related to its use in pedestrians are also on the rise (Nasar & Troyer, 2013). In 2015, a study conducted on five of the busiest intersections in Manhattan showed that a third of pedestrians crossing the street on a green light, and half of pedestrians crossing on a red light, were distracted by an electronic device (Basch et al., 2015). A more recent study conducted in 2019 found that 20% of pedestrians used their smartphone while crossing the street (Horberry et al., 2019).

Texting while walking is not the only ailment associated with smartphone use; stress and anxiety are two other known correlates (Elhai et al., 2016; Vahedi & Saiphoo, 2018). Stress and anxiety have been found to be both predictors (Boumosleh & Jaalouk, 2017; Cho et al., 2017; Gökçearslan et al., 2018; Han et al., 2017) and as results of (Chesley, 2005; Hawi & Samaha, 2017; Lee et al., 2014; Lepp et al., 2014; Murdock, 2013) smartphone use. Although most of the literature has focused on problematic smartphone use (PSU; i.e., smartphone use with the characteristics of addiction), even smartphone use devoid of problematic or addictive expression (NPSU) has been identified as both a result and a predictor of stress (Igarashi et al., 2005; Jin & Peña, 2010; Lepp et al., 2014). Different theories have been proposed to explain the mechanism behind stress and smartphone use. Some suggest that in the case of PSU, smartphone use is a way to cope with already-existing psychopathology (e.g., anxiety, depression) (Billieux, 2012). A similar theory has been proposed for NPSU, wherein one's smartphone may function as a coping tool against acute social stressors (Hunter et al., 2018). In cases of either PSU and NPSU, it is possible that an over-reliance on smartphones for reassurance-seeking purposes is also a feature and a maintenance factor of stress and anxiety disorders (Cougle et al., 2011; Nikmanesh et al., 2014). However, given the cross-sectional nature of the majority of these studies, the direction of the causality between stress and smartphone use is yet to be established (Vahedi & Saiphoo, 2018).

Additionally, to our knowledge no studies have examined the immediate effects of smartphone use on psychological and physiological stress. In a study by Hunter et al. (2018), the mere presence of the participants' smartphones helped reduce their perceived social exclusion as well as the concentration of salivary alpha amylase following the stressful event. However, no studies have examined whether actual smartphone use, rather than its mere presence, also has this effect. Moreover, no studies have reported on the effect of smartphone use on subsequent physiological stress. A review on technology's effect on physiological stress concluded that human interaction with computers can result in increased physiological stress markers (Riedl, 2012), but it is unclear whether this could also apply to smartphones. Because physiological and psychological stress have been shown to not always covary (Hjorskov et al., 2004; Ali et al., 2017; Campbell & Ehlert, 2011), it is possible that the effects of smartphone use on psychological and physiological stress are distinct.

In order to clarify the risks associated with TWW and related stress, it is also important to examine the effects of stress on cognition. Task-switching paradigms are a useful way of studying the cognitive processes involved in a dual-task like TWW. In task-switching experiments, participants "switch" between different tasks which require attention to a particular part of a stimulus (Kiesel et al., 2010). In order to accomplish this switch efficiently, participants must develop a mental representation of each task, which is commonly referred to as a *task-set* (Monsell, 1996). A robust phenomenon observed in these trials is that a "switch cost" exists in terms of response time and error rates. This switch cost can be attributed to the proactive interference of the previous task-set over the current task-set (Allport et al., 1994); when a participant switches from Task A to Task B, the A task-set momentarily interferes with the B task-set. Courtemanche et al. (2019)

used a task-switching paradigm to study the attentional effects of using one's smartphone while walking. They found that when participants had to switch between texting and identifying incoming stimuli in their environment, they were more likely to make mistakes than when they simply walked (Courtemanche et al., 2019). This study provides strong evidence that TWW incurs a cost in cognitive resources and is potentially dangerous for pedestrians.

It is possible that stress, a known modulator of high-level cognitive tasks, has an impact on cognition during TWW. However, the evidence on the effects of stress on high cognitive function is mixed. While stress has been shown to hinder performance in tasks such as the Wisconsin Card Sorting Test (Kalia et al., 2018) and on working memory (Oei et al., 2006), it has also been reported to facilitate task-switching (Lin et al., 2018; Steinhauser et al., 2007), increase performance in examinations (Kofman et al., 2006), and enhance working memory in certain conditions (Schoofs et al., 2013; Yuen et al., 2009). The underlying mechanisms for the effects of stress on cognition remain unclear. Some suggest that stress may impair higher-order cognitive faculties in order to facilitate well-learned and habitual behavior, which allows for faster responses (Gagnon & Wagner, 2016; Vogel et al., 2016). However, others propose that stress may help to easily relocate cognitive resources to stimuli that are relevant to the stressor (LeBlanc, 2009; Mather & Sutherland, 2011; Plessow et al., 2011). One of the first attempts to describe the relationship between stress and cognition was Yerkes' and Dodson's (1908) inverted U law, which posits that performance in cognitive tasks is best at an optimal stress level, and that too-high or too-low stress are detrimental to performance. In her review, Sandi (2013) adds that in tasks where the cognitive load is not excessive, mild stress tends to facilitate performance.

The effects of stress on task-switching specifically are also unclear. Goldfarb et al. (2017) found that cortisol response to stress enhanced participant's ability to update task information they held in working memory but reduced their performance when switching between different task demands. Similarly, Plessow et al. (2012) reported that stressed individuals took significantly longer to respond during task switches than task repetitions compared to controls. Liston et al. (2009) and Orem et al. (2008) also found that task-switching was impaired by chronic psychological stress. However, acute stress has also been reported to improve response time in task-switching trials without affecting accuracy (Lin et al., 2018).

Previous studies have also reported differences in the stress response between genders. For instance, several psychoneuroendocrinology studies have found more robust cortisol responses in men than in women (Kudielka & Kirschbaum, 2005; Stroud et al., 2002). Regarding psychological stress, some literature suggests that women are more likely to report higher stress levels than men (APA, 2010). Additionally, studies have found that women report greater negative affect than men immediately following a stressful event (Kelly et al., 2008). Because of these observed differences between genders, we elected to test for gender differences in our analyses.

The present study aims to clarify the relationship between stress and TWW, as well as the impact of stress on the cognitive demands of TWW. More specifically, we aimed to test whether stress is a predictor of TWW, and whether it may also be a result of TWW. Finally, we intended to test for the effects of stress on cognitive function when TWW. Three hypotheses were formulated for the purposes of this study:

Hypothesis 1: High pre-task stress, whether psychological (H1a) or physiological (H1b), will lead to greater smartphone use during an unrestricted walking task.

This prediction is based on the literature suggesting that smartphones can be used to soothe the negative emotions caused by chronic or acute stressors (Billieux, 2012; Hunter et al., 2018).

Hypothesis 2: Smartphone use will decrease psychological stress (H2a) and simultaneously increase physiological stress (H2b) when TWW.

These predictions are based on the literature outlining the short-term effects of smartphone use on psychological stress (Hunter et al., 2018) and on the literature examining the impact of technology use on subsequent physiological stress (Riedl, 2012).

Hypothesis 3: There is a curvilinear relationship between pre-task physiological stress and TWW performance, wherein moderate physiological stress leads to better performance.

This prediction is based on Yerkes' and Dodson's (1908) inverted U law, which suggests that cognitive performance is best at moderate stress levels. We made this prediction based on our biological motion perception task, which generates little cognitive load. According to some researchers, moderate stress tends to enhance performance, particularly in these types of tasks (Sandi, 2013).

2.2 Materials and methods

2.2.1 Study design and participants

Participants performed two tasks in the same order. The order of these tasks was not counterbalanced so that the effects of phone use in Task A could be assessed during Task B. Moreover, no direct comparisons were drawn between tasks A and B. We measured psychological and physiological stress before and after each task. To control for circadian fluctuations in cortisol (Lupien et al., 2007), all tests were conducted between noon and 6:00 PM. Participants were recruited primarily through our institution's pool of participants. A total of 80 participants between the ages of 18 and 49 participated in the study. All participants received compensation in the form of $50. This study was approved by our institution's Ethics Research Committee (Certificate #2019-3412).

2.2.2 Procedure

The stimulus used for the spatial recognition task was a dynamic point-light representation of a walking human form (Johansson, 1973). This point-light figure represented biological motion (BM) and was composed of 15 black dots which represented the head, shoulders, hips, elbows, wrists, knees, and ankles of the human figure. Participants were instructed to verbally identify the walker's direction (leftward or rightward) each time they heard the sound cue. We used a BM stimulus to conduct the experiment for two main reasons. First, this type of stimulus is ecologically valid in the context of texting while walking as a pedestrian, as the subject has to perceive this type of motion in her environment. Second, BM perception involves four stages (detection of animate motion, structure from motion, action perception, and style recognition) and thus requires a relatively important information processing effort from the visual system (Troje, 2008). Thornton et al. (2002) showed that, in a dual-task paradigm, performance on point-like walking direction identification was strongly affected by divided attention. We therefore consider that this task is ecologically valid for evaluating the switch cost of texting while walking in a pedestrian context.

The walker stimulus was constructed using the average motion capture data of 50 males and 50 females (Troje, 2008). The figures were projected on the frontal screen with a Marquee Ultra 8500 projector and a resolution of 1280 × 1024 pixels. The figures were 1.08 meters in height and were presented walking forward, with a rightward or leftward deviation angle of 3.5° (or -3.5°) from the participant. A 1000ms auditory cue was delivered at 20s intervals and 500ms before the presentation of each walking figure. Two speakers (Logitech, Switzerland) placed in front of the participants were used to deliver these cues. A stimulus response was considered correct when the participant accurately identified the direction in which the figure was headed (i.e., left or right).

The experimental procedure consisted of two main tasks and a practice task and lasted 50 minutes on average. Participants first performed a 3-minute practice task during which they walked on the treadmill and responded to the visual stimuli. The practice task was meant to habituate participants to the treadmill speed and to the stimulus. Participants were asked to put their phone on “do not disturb” mode and to place it face-down on the console in front of them before this task. A total of 6 walker figures were presented during practice. If participants got more than 4 out of 6 responses wrong, or if they missed or did not respond to the stimulus, the practice task was repeated. During a repeated practice, the RA gave the first 3 correct answers to the participant while being present in the room, and the participant was asked to respond to the last 3 trials. Once the practice task was over, participants were told they could remove the “do not disturb” mode on their phone. The participants’ personal phone remained on the front console for the duration of the next task.

The practice task was followed by two within-subject tasks which occurred in the same order for all participants: an unrestricted task (Task A) and a TWW task (Task B). Each task lasted 13 minutes and comprised 40 stimulus trials. During Task A, participants walked on the treadmill and responded to the walker stimulus. Before the task began, participants received the following information: (1) The task can be a little boring, (2) they should feel free to use their phone at any time if they wished, (3) using their phone was not dangerous or disturbing to the researchers, and (4) they should try nonetheless to respond correctly to the task and avoid taking or making calls. These instructions were devised to give participants free choice over whether and how long they used their personal phone during Task A. Unlike the other instructions given to participants, this information was not scripted; it was provided verbally by the research assistant (RA) in a spontaneous and familiar tone. Participants were not aware that their personal phone use would be monitored during this task. After Task A, participants who used their phone were asked to indicate via questionnaire the names of the applications they used and the estimated time they spent on each application.

After Task A, participants were instructed to store their personal phone in a locker outside of the room in preparation for the TWW Task (Task B). An RA then gave them the laboratory's iPhone. On average, there was a 5-minute delay between Tasks A and B. During Task B, participants walked on the treadmill and responded to the walker figure stimulus. At the same time, they participated in a conversation with a second RA located in an adjacent room via text message. Conversations were led by the RA through the use of a list of predefined topics. Topics were designed to be open-ended and to avoid strong emotional reactions (e.g., "What are your favorite television shows?", "Where have you traveled lately?"). The RA moved to a different conversation topic after 4-5 questions/answers on the same topic. The procedure used in Task B mirrors the one in Courtemanche et al. (2019).

Saliva samples were collected before and after each task, followed by a stress measurement scale. To calculate a baseline period for each participant, the two stress measures were taken upon arrival to the laboratory and before any instructions were given. A total of 4 paired saliva cortisol (C) and subjective stress (S) measures were thus obtained throughout the experiment: at baseline (C_0 and S_0), before Task A (C_1 and S_1), between Tasks A and B (C_2 and S_2), and after Task B (C_3 and S_3).

2.2.2 Apparatus

Our experiment reproduced the methodology used in Courtemanche et al.'s study (2019). The experiment took place in a room containing a regular consumer treadmill (Tempo Fitness, Wisconsin, USA) and a frontal projection screen. The treadmill speed was set to 0.8mph, a speed that was found to be the safest and most comfortable for performing the experiment during pretests. The treadmill was placed 2.44 meters away from the projection screen. During the uncontrolled task (Task A), the participant's personal smartphone was placed on the console before them; participants were allowed to use their phone if and when they wished. During the controlled TWW task (Task B), participants held a conversation via text message using a white iPhone 6S (Apple, USA). The conversation was carried out on Facebook Messenger, a popular messaging application.

2.2.3 Measures

Stress

Acute psychological stress levels were measured 4 times throughout the experiment: upon arrival to the laboratory (S_0), before the unrestricted task (S_1), between Tasks A and B (S_2), and after Task B (S_3) (Fig 1). We measured acute psychological stress with an abridged version of the State Anxiety Inventory (Spielberger et al., 1983). This version contains 6 statements that participants rate on a 4-point Likert scale ranging from 1 ("Not at all") to 4 ("Very"). Statements include, "I feel calm," "I feel tense," and "I feel preoccupied". Participants were instructed to respond according to how they felt in the present moment. This short version of the State Anxiety Inventory has been reported to yield comparable results to the longer version (Marteau & Bekker, 1992).

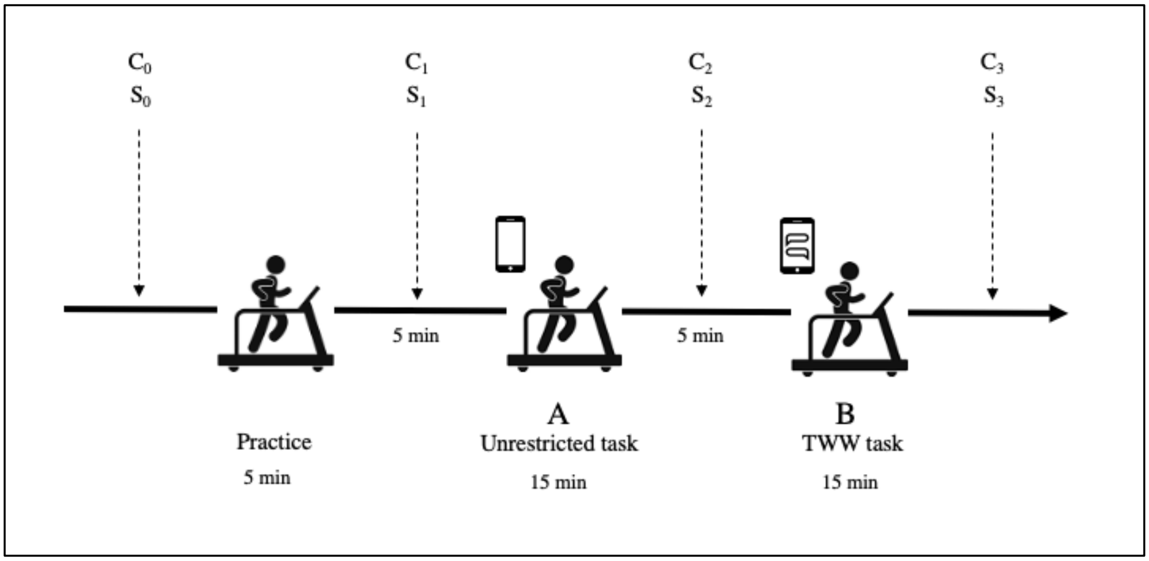
Phone use

Phone use during Task A was measured first as a binary variable (i.e., "yes" or "no"). In addition, we measured the total number of phone uses during Task A. For the purposes of this study, a "phone use" was defined as any time a participant either (a) picked up her phone and looked at her screen, or (b) returned her eyes to her phone screen if she had already been holding it. Attentional shifts resulting from the presentation of a walker stimulus (i.e., when a participant looked away from her phone to give her response) were not counted as a separate phone use. Additionally, we measured the amount of time it took participants to use their phone for the first time (i.e., time to first use) and the total amount of time spent using their phone during the task. Following Task A, participants were asked to list the applications they had used and to estimate the amount of time in minutes they had spent on each. From this information, we retained the type of application on which the participant spent the most time (type of application used). The type of application used was coded according to the following categories: communication (e.g., texting, SMS, WhatsApp), social media (e.g., Facebook, Instagram, Snapchat), games, entertainment (e.g., Youtube, Netflix), school- or work-related (e.g., email), internet (e.g., browser), or other. Phone use (yes/no), number of uses, total time, time to first use, and type of application used were all the phone-use variables included in our statistical analysis.

Saliva cortisol

Saliva samples were collected 4 times throughout the experiment: upon arrival to the laboratory (C_0), before Task A (C_1), between Tasks A and B (C_2), and after Task B (C_3) (Fig 1). Each sample was approximately 2ml. Frozen samples were brought to room temperature and centrifuged at 1500 × g (3000 rpm) for 15 min. High-sensitivity enzymeimmuneassays were used (Salimetrics®, No. 1-3102, sensitivity: 0.012–3 μg/dl). Inter-assay and intra-assay coefficients of variance were below 4.69%. All assays were duplicated and averaged.

Figure 1 - Test methodology



2.2.5 Statistical Analysis

Statistical analyses were performed using SAS 9.4 for Windows. Sex and age were included in every model as covariates. In addition, given the presence of large sex differences in physiological response to stress (Kudielka & Kirschbaum, 2005), additional separate analyses were performed for women and for men, and p values were corrected using the Bonferroni correction in these instances.

Cortisol and psychological stress measures were adjusted for baseline in the following way:

$$\delta C_m^p = C_m^p - C_0^p$$

Where p refers to a given participant, C_m refers to a given cortisol measure taken after baseline (i.e., C_1, C_2, or C_3), and C_0 refers to cortisol measured at baseline.

Additionally, we calculated cortisol changes during tasks (i.e., delta cortisol) in the following way:

$$\Delta C_{m,n}^p = C_m^p - C_n^p$$

Where p refers to a given participant, C_m refers to a given cortisol measure taken after a task (i.e., C_2, or C_3), and C_n refers to a given cortisol measure taken before that task (i.e., C_1 or C_2).

The same manipulations were performed on the psychological stress measures collected via questionnaire in order to obtain δS and ΔS.

To assess the effects of phone use in the first task on subsequent physiological and psychological stress levels, the order of Tasks A and B remained the same for all participants. Moreover, no direct comparisons were drawn between Tasks A and B, as this was not necessary to verify our hypotheses. The following analyses were performed for each hypothesis:

H1: we used a linear regression model to verify whether psychological (H1a) or physiological (H1b) stress predicted **any of** the phone use variables (yes/no), number of uses, total time, time to first use, and type of application used).

H2: we used a linear regression model to verify whether the phone use variables measured in Task A predicted psychological (H2a) and/or physiological (H2b) stress after Task A.

H3: we used a linear regression model with a quadratic term to verify whether there was a quadratic relationship between performance in Task B and stress measured after Task A.

For H1 and H2, we also elected to test for curvilinear relationship, as we suspected that the relationship between stress and phone use may not be linear.

2.3 Results

2.3.1 Participant characteristics

A total of 80 participants participated in the study, including 44 (55%) women and 36 (45%) men. Demographics and a breakdown of main task variables are presented in Table 1. The mean age was 23.6 years (SD = 5.34). A total of 53 participants (66%) used their personal phone during Task A. Average usage time was 4.4 (SD = 4.65) minutes, and average time to first use was 2.9 minutes (SD= 3.52). The mean number of phone uses throughout the task was 3.36 (SD = 4.31). The top three types of application most used were social media (n=28, 52%), communication (n=13, 24%) and games and other (n=4, 7%). On average, participants responded correctly to 82% of the trials in Task A and to 81% of the trials in Task B, which is in line with previous results from Léger et al. (2020) and Courtemanche et al. (2019).

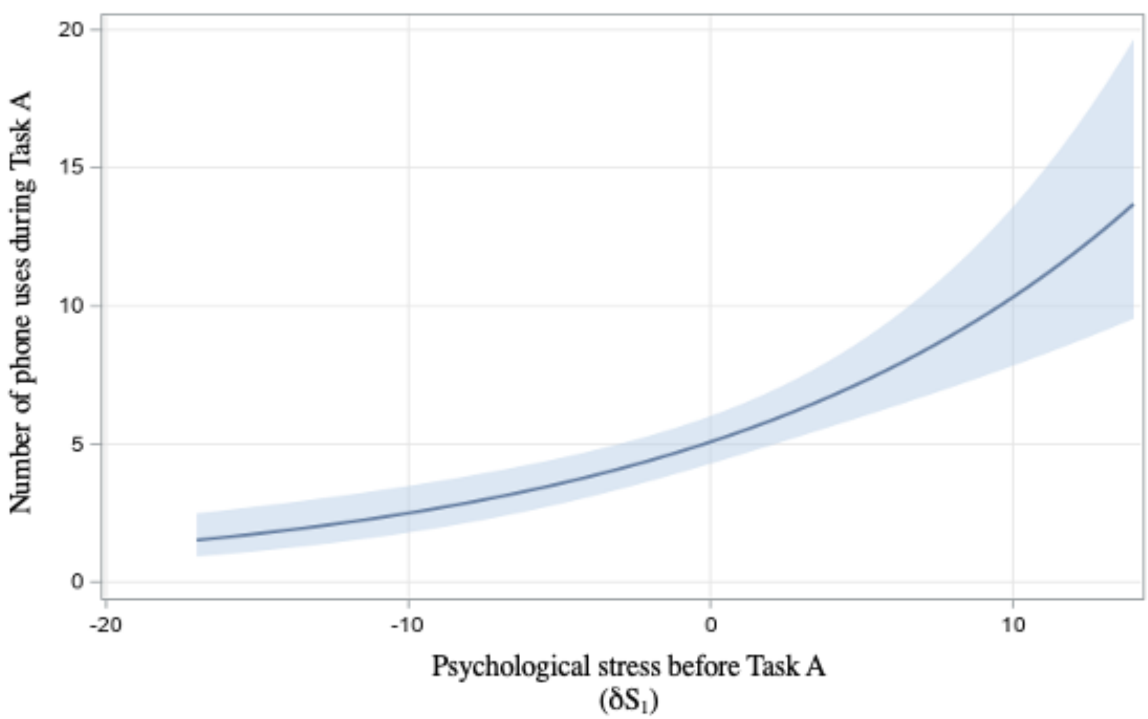
Table 2.1 - Demographics and task variables by sex

	Males	**Females**
n	36	44
Average age	25.13 (SD=6.26)	22.39 (SD=4.10)
Task A		
Accuracy (% correct)	86.57 (SD=13.18)	78.22 (SD=16.14)
Used phone (yes)	27	26
Total time of use (avg. mins.)	5.03 (SD=4.68)	3.9 (SD=4.63)
Time to first use (avg. mins.)	2.39 (SD=3.05)	3.51 (SD=3.99)
Number of phone uses (avg.)	3.97 (SD=3.96)	2.86 (SD=4.57)
Type of app most used	Social media	Social media
Task B		
Accuracy (% correct)	84.15 (SD=14)	79.87 (SD=14.66)
Average cortisol (µg/dl, SD)		
C_0	0.19 (0.12)	0.20 (0.17)
C_1	0.17 (0.10)	0.18 (0.17)
C_2	0.15 (0.08)	0.14 (0.11)
C_3	0.12 (0.06)	0.11 (0.06)
Average state anxiety inventory score (SD)		
S_0	30.17 (8.05)	33.12 (7.96)
S_1	29.67 (6.44)	32.81 (7.22)
S_2	31.58 (7.53)	32.47 (8.13)
S_3	30.02 (6.73)	31.81 (7.32)

2.3.2 Relationship between stress and phone use (H1)

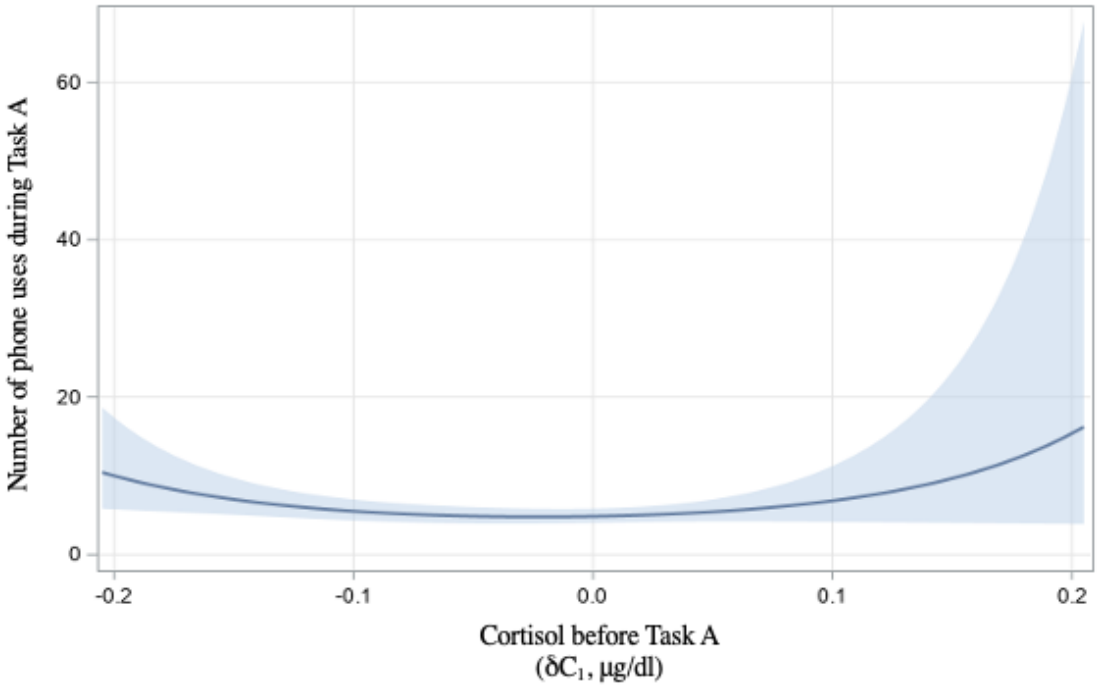
Our first hypothesis was concerned with stress as a predictor of texting while walking. We expected that stress, either physiological (H1a) or psychological (H1b), would predict smartphone use in Task A. The dependent variables included in the analysis were the phone use variables measured during Task A (phone use, total time of use, number of uses, time to first use). Absolute psychological and physiological stress before Task A were not related to the probability of using one's phone, to total time of use, nor to time to first use. However, baseline-adjusted psychological stress before Task A (δS_1) was associated with a greater number of phone uses ($F = 29.95$, $p < .0001$, $DF = 48$, $SE = 0.0129$) (Fig 2). Covariates age and sex were not significantly associated with phone uses in this analysis ($F = 1.27$, $p = .26$; $F = 1.56$, $p = .21$).

Figure 2 - Relationship between psychological stress before Task A and number of phone uses



In addition, baseline-adjusted cortisol before Task A (δC_1) had a quadratic effect on the number of times participants used their phones during the task ($F = 4.3$, $p = .04$) (Fig 3). Covariates age and sex were not significantly associated with phone uses in this analysis ($F = .18$, $p = .67$; $F = .25$, $p = .62$).

Figure 3 - Relationship between physiological stress before Task A and number of phone uses



In light of these analyses, we find that H1 is supported. Absolute stress measures, whether psychological or physiological, were not associated with the probability of using one's phone during Task A. However, higher baseline-adjusted psychological stress before Task A predicted a greater number of phone uses during the task, and a quadratic relationship was found between baseline-adjusted physiological stress before Task A and the number of phone uses.

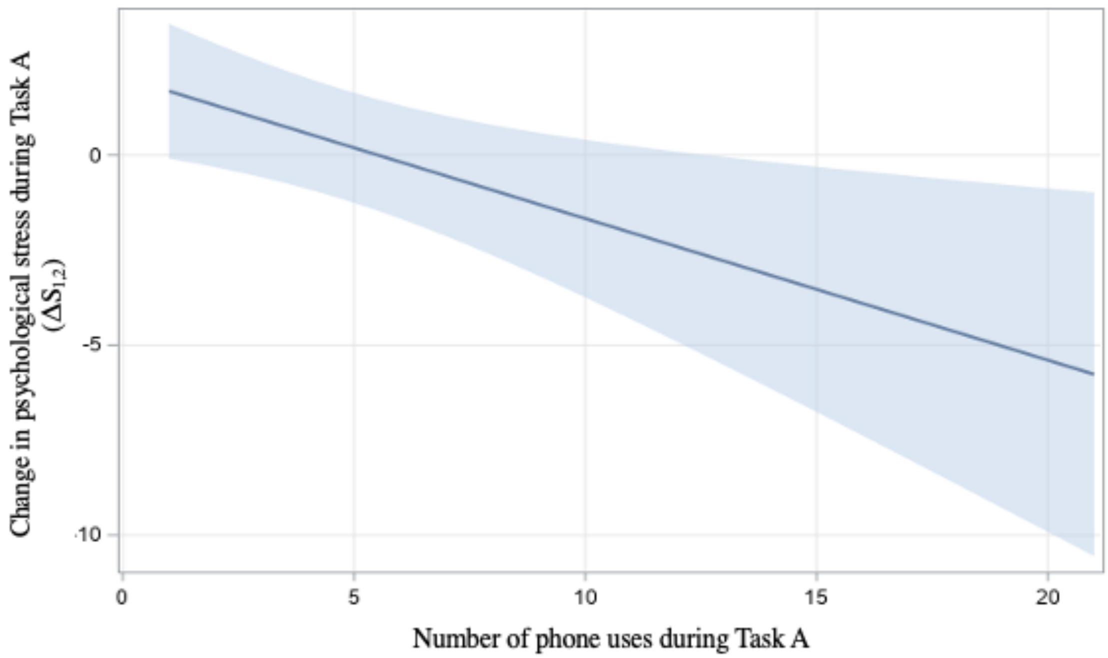
2.3.3 Effects of phone use on stress (H2)

Our second hypothesis tested the effects of using one's phone during Task A on psychological and physiological stress. We expected that using one's phone during Task A would predict a reduction of psychological stress (H2a) and, simultaneously, an increase of physiological stress (H2b).

In regard to H2a, phone use (yes/no), time to first use, and total time of use were not significantly related to psychological stress during Task A. However, there was a significant negative relationship between phone uses and changes in psychological stress throughout the task (ΔS_1); this relationship was only significant in women ($F = 6.01$, $p =$

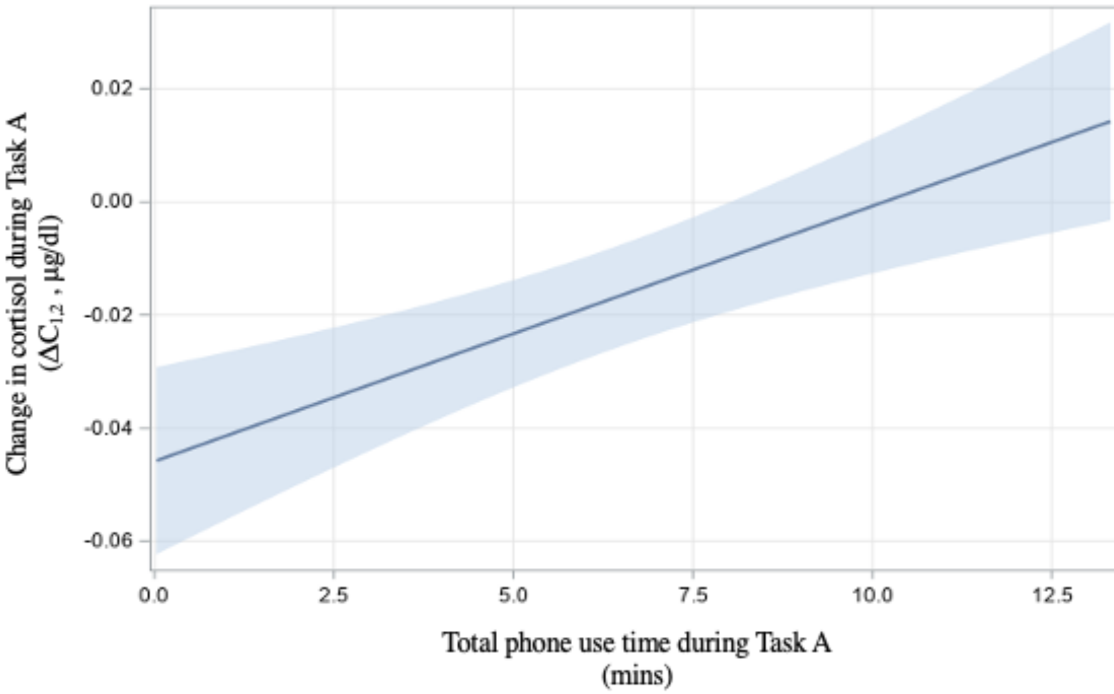
.0452, DF = 22, SE = 0.152) (Fig. 4). Covariate age was not significantly associated with perceived stress in this analysis (F = 0.1, p = 0.7508).

Figure 4 - Relationship between number of phone uses and psychological stress (H2a)



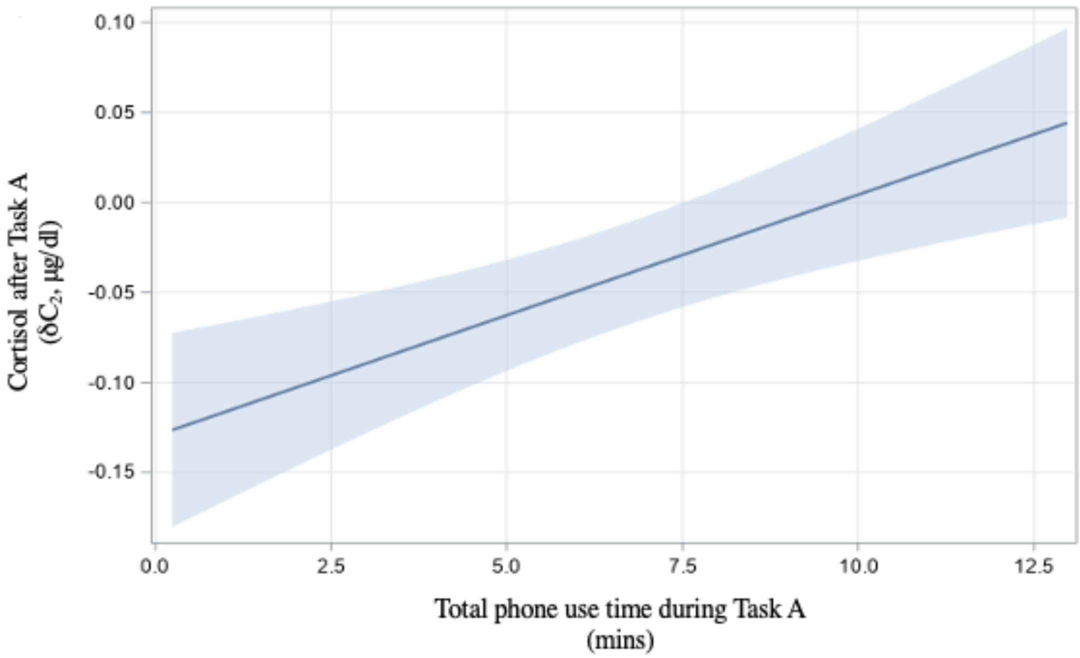
Regarding H2b, we found no relationship between phone usage (yes/no), time to first use, or number of uses and physiological stress during Task A. We found that longer phone use (in minutes) during Task A predicted greater increases in cortisol during the task (ΔC_1) (F = 16.90, p = .0002) (Fig 5). Sex did not have a significant effect on cortisol change (F = 1.78, p = .188) in this analysis, but age was positively associated with cortisol change (F = 9.6, p = .0032).

Figure 5 - Relationship between phone use time and physiological stress (H2b)



An additional analysis revealed that longer phone use time predicted higher baseline-adjusted cortisol after Task A, but this relationship was only significant in men ($F = 12.23$, $p = 0.0038$, $DF = 24$, $SE = 0.003$) (Fig 6). Covariate age was not significant in this analysis ($F = 2.84$, $p = 0.1052$).

Figure 6 - Relationship between phone use time and physiological stress (in men)

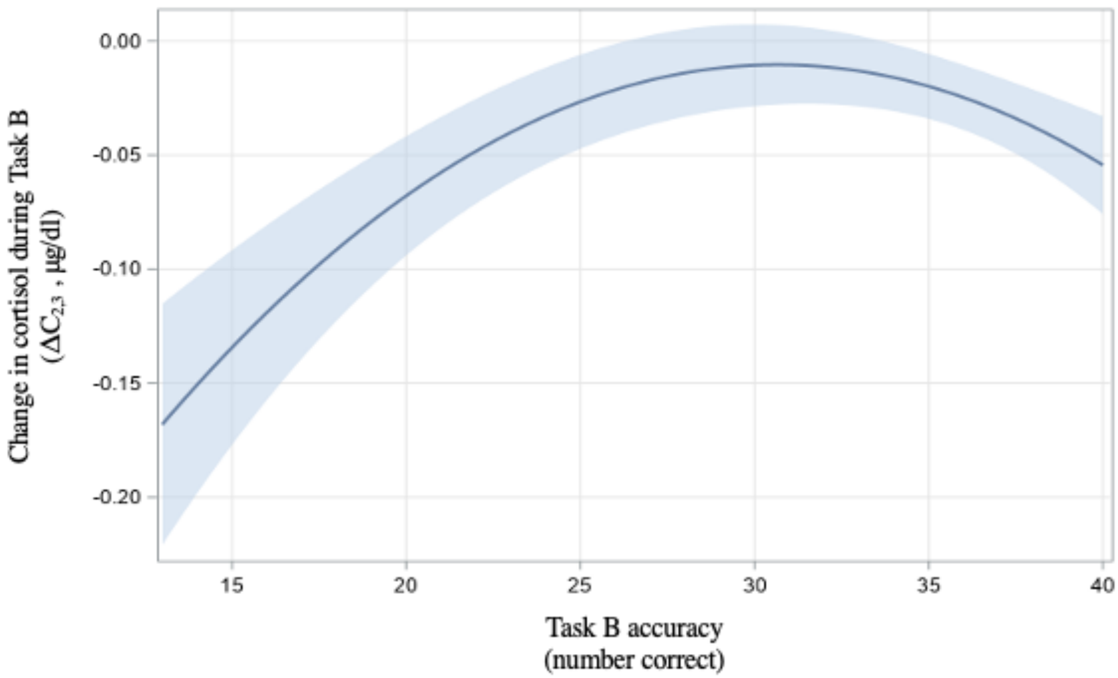


We thus found H2 to be partially supported: a higher number of phone uses did decrease psychological stress during Task A, but this effect was significant only in women (H2a). Additionally, longer phone use during Task A predicted greater increases in cortisol during the task (H2b). Moreover, an additional analysis revealed that longer phone use also predicted higher cortisol levels after Task A, but this effect was only significant in men.

2.3.4 Effects of cortisol on performance (H3)

Our third hypothesis was concerned with the effects of cortisol on performance. We predicted that there would be a curvilinear relationship between cortisol before Task B and performance in Task B. Statistical analyses revealed no effects of absolute cortisol measured before Task B on subsequent performance. However, using the changes in cortisol during the task (ΔC_2), we found that throughout Task B, a curvilinear relationship existed between cortisol changes and accuracy ($F = 24.65$, $p < 0.0001$, $DF = 73$, $SE = 0$) (Fig 7).

Figure 7 - Relationship between Task B performance and cortisol (H3)



We therefore find H3 to be partially supported; cortisol before Task B had no significant effect on subsequent performance, but moderate performance was associated with higher cortisol changes during the task.

2.4 Discussion

The purpose of the present study was to examine the relationship between psychological and physiological stress and smartphone use in the context of texting while walking (TWW).

Our first objective was to examine stress as a potential antecedent of TWW in the unrestricted task, where participants were free to use their phone if they wished. We found that perceived stress before the unrestricted task was associated with a greater number of phone uses (H1a). Thus, participants who experienced an increase in psychological stress before the unrestricted task relative to baseline were more likely to use their phones several times during this task. This finding is congruent with the literature suggesting that psychological stress can be a precursor to smartphone use (Boumosleh & Jaalouk, 2017; Cho et al., 2017; Kuang-Tsan & Fu-Yuan, 2017). More specifically, some researchers suggest that smartphones can serve as a strategy to reduce psychological stress (Hunter et al., 2018). That participants who experienced increases in psychological stress proceeded to use their phones several times seems congruent with this view. Interestingly, this result is specific to the number of phone uses, and not to the total time of use. It is therefore possible that increases in psychological stress predict a greater tendency or need to check one's phone in a compulsive manner, rather than the tendency to use it longer.

Changes in physiological stress, as well, were found to be a determinant of smartphone use. We found that cortisol before the unrestricted task had a quadratic effect on the number of phone uses during the task (H1b). This suggests that those participants who experienced either a drop or an increase in cortisol relative to baseline before the task were most likely to use their phones several times. To our knowledge, no literature has yet studied physiological stress as a potential predictor of smartphone use. However, these results suggest that continual or impulsive smartphone checking behavior could be associated with cortisol fluctuation. It is possible that phone checking behavior in those for whom cortisol decreased was due to boredom or to a need for stimulation, and in those from whom cortisol increased, to a need for distraction in response to stress.

Our second objective was to investigate the effects of TWW on psychological and physiological stress. To achieve this, stress levels after the unrestricted task were compared between participants who used their phones extensively and those who used it less. We found that a greater number of phone uses predicted lower psychological stress, through this relationship was only significant in women (H2a). Additionally, longer phone use (in minutes) during the unrestricted task predicted greater increases in cortisol (H2b) during the task. Cortisol therefore tended to increase as the time spent using one's phone increased. There were sex differences regarding physiological and psychological stress reactions. In men, an additional analysis showed that longer phone use was related to higher cortisol after the unrestricted task. In women, a higher number of phone uses was related to a decrease in psychological stress during the task. These results are somewhat congruent with previous literature which found sex differences in physiological reactions to stress. Most psychoneuroendocrinology studies report more robust cortisol responses in men than in women (Kudielka & Kirschbaum, 2005; Stroud et al., 2002). Additionally, in regard to women's stress response to phone use during the unrestricted task, we observed a similar effect to that of Hunter et al. (2018)'s social blanket theory: the availability of the participant's phone, and in this case, more phone checking behavior (i.e., phone uses) seemed to reduce psychological stress during the task. There is some evidence indicating that women tend to report higher levels of psychosocial stress than men (Anbumalr et al., 2017; Misigo, 2015; Xu et al., 2015). Our results seem to agree with this evidence.

Our third objective was to evaluate the effects of physiological stress associated with smartphone use on performance in the TWW task (i.e., Task B; H3). We found no effects of cortisol measured before the TWW task on subsequent performance. However, additional post hoc analyses revealed that performance in the TWW task had a quadratic effect on cortisol levels throughout the task (i.e., delta cortisol). This suggests that during the TWW task, cortisol tended to decrease the most for those participants who performed very well or very poorly. Those who performed moderately well experienced the highest levels of cortisol. These participants were likely making a conscious effort to respond to the perception task, while the high performers likely found the task too easy, and the low performers, too hard. It is important to note that participants did not receive feedback during the task and were therefore unaware of their general performance. However, we believe that an inconsistent pattern of response (i.e., moderate performance) may reflect conscious effort, whereas consistent performance, be it correct or incorrect, likely indicates that participants did not try to adapt or change their responses as they walked. It is possible that participants who exerted a conscious effort to perform throughout the task experienced higher levels of cortisol as a result.

Our study makes several contributions to the literature on stress and phone multitasking. First, we found confirmatory evidence for the theory advanced by Billieux (2012) and Hunter et al. (2018) whereby smartphone use can act as a coping mechanism for stress. Our study revealed that higher psychological stress before the unrestricted task led to a greater number of phone uses. This suggests that phone use, in particular repeated phone-checking behavior, could be a response to perceived stress. In addition, our study was the first, to our knowledge, to directly examine the effect of cortisol levels on subsequent phone use. In this regard, we found that changes in cortisol relative to baseline (i.e., either drops or increases in cortisol) predicted more phone uses during the unrestricted task.

The present study also helps to clarify the effect that phone multitasking can have on stress. We found confirmatory evidence for the theory proposed by Hunter at al. (2018) whereby phones (in this case, not only their presence, but actual use) can help reduce psychological stress. In our study, a greater number of phone uses predicted lower psychological stress, although this relationship was only significant in women. Moreover, this finding and the above corroborate the theories proposed by Cougle et al. (2011) and Nikmanesh et al. (2014) implying that there is a cyclical relationship between stress and smartphone use. Smartphone application developers could use this information to introduce system warnings related to smartphone use and stress. For instance, users could be notified and made aware of the dangers associated with frequent phone-checking behavior and its relationship with stress. In addition, public health campaigns intending to reduce TWW may use this information to caution pedestrians on the effects that stress can have on both their smartphone use and their security.

Finally, the present study also examined the effect of physiological stress on performance in a TWW task (i.e., the ability to correctly identify the direction in which another walker is going). In this regard, we found confirmatory evidence for Yerke's and Dodson's (1908) inverted U law, whereby peak cortisol levels are associated with moderate performance. This likely implies that making a conscious effort to perform well (in this case, to successfully identify and avoid obstacles during distracted walking) can lead to an increase in cortisol. Thus, making a conscious effort to multitask can be physiologically stressful.

The results of this study should be interpreted in view of its limitations. Firstly, while our study offers a first exploration of the link between stress and phone use, it did not manipulate stress in participants. In order to confirm a causal relationship between stress and phone use, therefore, further studies will need to be conducted where stress is also manipulated (for example, through the use of the Trier Social Stress Test). It is also important to consider that our physiological stress measures were highly time-sensitive;

it is therefore possible that any given cortisol measure was either related to the current task (e.g., the use of participant's phone) or to the participant's apprehension of the next task. Since participants knew the order in which they would perform the tasks, their stress levels in the unrestricted task may have been influenced by their expectation of the TWW task. Moreover, the stress generated by phone use in the unrestricted task, particularly the psychological stress, may not have been sufficient to significantly affect performance in the subsequent Task. A study in which stress is more severe may show stronger results. Finally, we did not measure reaction time during the TWW task (i.e., time between stimulus onset and response), which prevented us from examining the effects of stress on this aspect of cognitive performance.

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Conclusion

L'objectif de ce mémoire était d'étudier la relation entre l'utilisation du téléphone intelligent dans un contexte piétonnier et le stress. Plus spécifiquement, nous nous sommes intéressés à comment le stress influence l'utilisation du téléphone en marchant, comment cette dernière influence le stress, et à l'impact du stress sur la capacité des participants à texter en marchant. Ce mémoire a permis d'enrichir nos connaissances sur la relation entre le stress et le téléphone intelligent en fournissant des résultats sur les effets immédiats de l'utilisation du téléphone sur le stress et du stress sur l'utilisation du téléphone. De plus, ce mémoire inclut une des seules études permettant d'étudier le stress physiologique en rapport avec l'utilisation du téléphone et de le comparer au stress psychologique. Finalement, ce mémoire réunit les domaines de la cognition reliée à la multitâche et de l'utilisation du téléphone intelligent.

Afin de répondre à nos questions de recherche, nous avons reconstitué l'expérience en laboratoire conçue par Courtemanche et al. (2019) où les participants marchent sur un tapis roulant et indiquent, suite à un signal sonore, la direction dans laquelle une figure d'un marcheur se dirige. Lors d'une première tâche, nous avons donné aux participants le choix d'utiliser leur téléphone personnel s'ils le désiraient. Lors d'une deuxième tâche, ils ont participé à une conversation via messagerie texte avec une auxiliaire de recherche. Avant et après chaque tâche, nous avons mesuré le stress psychologique par questionnaire et le stress physiologique par collecte de salive. Un total de 80 participants ont complété l'étude.

Ce chapitre présente un rappel des questions de recherche avec les résultats qui s'y rattachent, ainsi que les contributions de ce mémoire, ses limites et les avenues de recherche future.

Rappel des questions de recherche et résultats

Les résultats de ce mémoire ont permis de répondre aux questions de recherche suivantes :

1.Comment le stress, autant psychologique que physiologique, influence-t-il la propension à utiliser le téléphone intelligent en marchant?

2. Comment l'utilisation du téléphone en marchant influence-t-elle les niveaux subséquents de stress psychologique et physiologique?

3. Quel est l'impact du stress physiologique dans notre capacité à texter en marchant?

Notre première hypothèse, liée à la première question de recherche, prévoyait qu'un plus grand stress (autant psychologique que physiologique) prédirait l'utilisation du téléphone durant la tâche libre. Nos résultats ont révélé que le stress psychologique et physiologique étaient associés différemment à l'utilisation du téléphone. Une augmentation du stress psychologique avant la tâche libre prédit plus d'utilisations du téléphone, ce qui indique que plus le stress psychologique augmentait, plus les participants avaient tendance à activer leur téléphone lorsqu'ils marchaient. Quant au stress physiologique, une augmentation du cortisol avant la tâche libre avait un effet quadratique sur le nombre d'utilisations; les participants qui ont subi un changement dans leur niveau de cortisol (qu'il soit positif ou négatif) étaient ceux qui ont utilisé leur téléphone le plus souvent. Les résultats de notre étude ont partiellement confirmé notre hypothèse: il y a une relation linéaire positive entre le stress psychologique et le nombre d'utilisations du téléphone intelligent pendant la tâche. Cependant, la relation non-linéaire entre le stress physiologique et l'utilisation était inattendue. Cette constatation est d'autant plus importante que la recherche sur le stress physiologique et le téléphone intelligent est insuffisante.

Notre deuxième hypothèse prévoyait que l'utilisation du téléphone pendant la tâche libre prédirait à la fois un stress psychologique moins élevé et un stress physiologique plus élevé. Les résultats de notre étude confirment partiellement cette hypothèse : chez les femmes, le nombre d'utilisations du téléphone était effectivement associé à une diminution du stress psychologique au cours de la tâche. Quant au stress physiologique, il avait tendance à augmenter au cours de la tâche lorsque le temps total d'utilisation augmentait. De plus, chez les hommes, le temps d'utilisation du téléphone était positivement lié à un plus grand stress physiologique après la tâche libre. Pour conclure, l'effet prédit de l'utilisation du téléphone sur le stress psychologique a été vérifié uniquement chez les femmes. Quant à l'effet du stress physiologique (mesuré après la tâche), il n'a été vérifié que chez les hommes. Cependant, le stress physiologique avait tendance à augmenter simultanément avec le temps d'utilisation pour tous les participants.

Notre troisième question de recherche se penchait sur les effets du stress psychologique sur la performance des participants dans la tâche contrôlée. Nous avions prédit que le stress physiologique modéré serait associé à une meilleure performance. Nos résultats ont révélé que le cortisol avant la tâche contrôlée n'avait aucun effet sur la performance. Cependant, nous avons remarqué qu'une performance modérée était associée à de plus hauts niveaux de cortisol. Ainsi, les participants ayant une performance très basse ou très élevée étaient le moins susceptibles de subir des hausses de cortisol.

Contributions

Ce mémoire offre plusieurs contributions à la littérature sur le stress et l'utilisation du téléphone intelligent. Dans un premier temps, notre étude est la première à étudier la relation entre le stress et l'utilisation multitâche du téléphone intelligent dans un contexte piétonnier. Notre étude fournit donc davantage d'informations sur les dangers associés à l'utilisation du téléphone intelligent en marchant : cette activité multitâche peut être un résultat du stress et peut également générer du stress. Nos observations unissent donc la littérature sur le stress et le téléphone intelligent avec celle de son utilisation en contexte multitâche. Notre étude a le potentiel d'être une étape vers d'autres expérimentations sur l'utilisation du téléphone chez les piétons et le stress qui s'y rattache.

Dans un deuxième temps, notre étude est parmi les premières à examiner la relation entre l'utilisation du téléphone intelligent et le stress physiologique. Comme mentionné précédemment, peu d'études se sont penchées sur les effets du téléphone intelligent sur des mesures physiologiques. Aussi, peu d'études ont examiné autant l'effet de l'utilisation du téléphone sur le stress physiologique que l'effet de ce-dernier sur l'utilisation du téléphone. Ainsi, notre étude offre des conclusions préliminaires sur cette relation.

Finalement, ce mémoire offre des contributions d'un point de vue méthodologique. En reproduisant la méthode utilisée par Courtemanche et al. (2019), notre étude aura contribué à consolider l'utilisation de cette méthode pour l'étude du multitâche au téléphone en marchant. De plus, notre étude est la première à ajouter à cette méthode l'utilisation des collectes de salive pour mesurer le stress physiologique. Cette étude, ainsi que celle de Courtemanche et al. (2019), pourront donc offrir un schéma directeur à des chercheurs s'intéressant à l'étude du multitâche au téléphone en marchant en laboratoire.

Limites et recherche future

Les résultats de ce mémoire doivent être interprétés à la lumière de ses limitations. Dans un premier temps, n'ayant pas manipulé le stress chez les participants, il nous est impossible d'établir un lien causal entre le stress et l'utilisation du téléphone en marchant. Dans un deuxième temps, le stress généré par l'utilisation du téléphone durant la tâche libre aurait pu être insuffisant pour affecter la performance de façon significative à la tâche restreinte. Il faut également noter que nos mesures de stress étant sensibles au temps, il nous est impossible de déterminer si le stress mesuré à un moment déterminé est lié à la tâche en cours (i.e., l'utilisation du téléphone) ou à l'appréhension des tâches futures. Finalement, notre étude n'incluait pas la mesure du temps de réaction chez les participants; une telle mesure aurait peut-être révélé les effets du stress sur la performance plus clairement.

Lors de recherches futures, il serait intéressant de reproduire notre expérience tout en manipulant le stress chez les participants et en comparant ces-derniers à un groupe contrôle. Une prochaine étude pourrait, par exemple, utiliser le test de stress social de Trier (Kirschbaum et al., 1993) pour induire le stress chez un groupe de participants avant l'expérience. Ceci permettrait d'établir un lien causal entre l'utilisation du téléphone intelligent et le stress. De plus, cette modification aurait le potentiel d'induire suffisamment de stress psychologique pour que ce-dernier ait un effet perceptible sur la performance des participants. Des expériences futures pourraient également varier le type de tâche qui est effectuée au téléphone pendant que le participant marche. Dans notre étude, les participants ont effectué une tâche libre (non-restreinte) et ont ensuite envoyé des messages texte. Des études futures pourraient isoler l'impact de tâches spécifiques, telles que l'utilisation de jeux mobiles, de médias sociaux, ou de la réalité augmentée sur le stress.

Des études futures pourraient également optimiser la méthode utilisée dans la présente étude afin d'augmenter sa validité et l'adapter à différents contextes. Par exemple, il pourrait être intéressant de rendre l'expérience plus immersive en utilisant la réalité augmentée. Cette méthode pourrait également servir à tester des interventions technologiques destinées à réduire les risques liés au multitâche dans un contexte de laboratoire. Par exemple, des interventions sur l'interface utilisateur telles que celle développée par Lu & Lo (2019) pourraient être testées avec cette méthodologie.

Pour conclure, plus de recherche sera nécessaire pour une compréhension plus poussée de la multitâche avec le téléphone intelligent et le stress qui s'y associe, mais ce mémoire aura contribué à mieux articuler les questions. Des études futures devront explorer le stress dans des contextes d'utilisation du téléphone autres que la marche distraite. Ces contextes pourraient être au travail, lors de tâches spécifiques (e.g., l'écriture de courriels, l'analyse de données) ; en déplacement, tel qu'en voiture ou à vélo ; ou dans des contextes sociaux (e.g., en conversation). L'étude de ces situations nous permettra de mieux comprendre le multitâche avec un téléphone intelligent et sa relation avec le stress d'une manière globale.

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Annexes

DIRECTIVES ACCOMPAGNANT UN QUESTIONNAIRE ANONYME

L'effet du stress sur l'impact cognitif d'utiliser son téléphone en marchant

Vous trouverez dans les prochaines pages un questionnaire anonyme auquel nous vous invitons à répondre. Ce questionnaire a été développé dans le cadre d'une mémoire à HEC Montréal.

Répondez sans hésitation aux questions incluses dans ce questionnaire, car ce sont vos premières impressions qui reflètent généralement le mieux votre pensée. Il n'y a pas de limite de temps pour répondre au questionnaire, bien que nous ayons estimé que cela devrait vous prendre environ 15 minutes.

Les renseignements recueillis sont anonymes et resteront strictement confidentiels; ils ne seront utilisés que pour l'avancement des connaissances et la diffusion des résultats globaux dans des forums savants ou professionnels.

Le fournisseur de collecte de données en ligne s'engage à ne révéler aucune information personnelle (ou toute autre information relative aux participants de cette étude) à d'autres utilisateurs ou à tout autre tiers, à moins que le répondant consente expressément à une telle divulgation ou que celle-ci soit exigée par la loi.

Vous êtes complètement libre de refuser de participer à ce projet et vous pouvez décider en tout temps d'arrêter de répondre aux questions. Le fait de remplir ce questionnaire sera considéré comme votre consentement à participer à notre recherche et à l'utilisation des données recueillies dans ce questionnaire pour d'éventuelles recherches. Puisque le questionnaire et anonyme, une fois votre participation complétée, il vous sera impossible de vous retirer du projet de recherche, car il sera impossible de déterminer quelles réponses sont les vôtres.

Si vous avez des questions concernant cette recherche, vous pouvez contacter le chercheur principal, Gabrielle Mourra, au numéro de téléphone ou à l'adresse de courriel indiqués ci-dessous.

Le comité d'éthique de la recherche de HEC Montréal a statué que la collecte de données liée à la présente étude satisfait aux normes éthiques en recherche auprès des êtres humains. Pour toute question en matière d'éthique, vous pouvez communiquer avec le secrétariat de ce comité au (514) 340-6051 ou par courriel à cer@hec.ca.

Merci de votre précieuse collaboration!

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Anxiété chronique et réactionnelle (Y-6)

Vous trouverez ci-dessous un certain nombre d'énoncés que les gens ont déjà utilisés pour se décrire. Lisez chaque énoncé, puis en encerclant le chiffre approprié à droite de l'énoncé, indiquez comment vous vous sentez **maintenant**, c'est-à-dire **à ce moment précis.** Il n'y a pas de bonnes ou de mauves réponses. Ne vous attardez pas trop longtemps sur un énoncé ou l'autre mais donnez la réponse qui vous semble le décrire le mieux les sentiments que vous éprouvez **présentement**.

1. Je me sens calme………………………………………………………….. 1 2 3 4
2. Je suis tendu(e)………………………………………………………… 1 2 3 4
3. Je me sens bouleversé(e)……………………………………………… 1 2 3 4
4. Je me sens détendu(e)………………………………………………….. 1 2 3 4
5. Je me sens satisfait(e)………………………………………………….. 1 2 3 4
6. Je suis préoccupé(e)…………………………………………………… 1 2 3 4

1 = pas du tout, 2 = un peu, 3 = modérément, 4 = beaucoup

Questionnaire d’utilisation du téléphone personnel

Veuillez lister les applications que vous avez utilisées sur votre cellulaire pendant la dernière tâche, ainsi que le temps moyen en minutes que vous avez passé à les utiliser.

Vous avez marché 13 minutes en tout.

Exemples :
Facebook, 5 min
Instagram, 2 min

Si vous n'avez pas utilisé votre cellulaire, veuillez inscrire "rien" et envoyer le formulaire.