Classifying computer-mediated communication (CMC) interruptions at work using control as a key delineator

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Classifying Computer-Mediated Communication (CMC) Interruptions at Work Using Control as a Key Delineator

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Abstract

Computer-mediated communication (CMC) interruptions are a common feature of people's work activity. In studying interruptions, researchers can understand how people manage and co-ordinate their work when faced with multiple, often competing, demands. However, CMC interruptions are characteristically different from each other and impact people's work performance in different ways. In this theoretical paper we define and differentiate between computer-mediated communication (CMC) interruptions, according to the level of control people are able to exert over an interruption at different points in the delivery timeline. Informed by the extant interruptions literature and Action Regulation Theory, a classification framework is provided, to help researchers and work designers distinguish which types of real-world CMC interruption are more or less disruptive, based on levels of control. Using the developed framework, two key research propositions are made, which we encourage future research to attend to. Unique contributions and implications of this paper are discussed.

Keywords: Action Regulation Theory; computer-mediated communication (CMC), Human-Computer Interaction; Email; Mobile Communications.

Introduction

Computer-mediated communication (CMC) interruptions heavily permeate modern working life and include email, text messages, telephone calls, skype, instant messenger, pager notifications and the like. Interruptions from these sources vary in the degree to which they can be accepted or deferred (Bogunovich and Salvucci, 2011), depending on the extent to which workers are able to exert control over their response. Yet, interruptions research has traditionally been undertaken in experimental settings where participant control is largely absent. For example, single interruptions are forcibly presented during an ongoing task (Baethge, Rigotti and Roe, 2015; Grundgeiger, Sanderson, MacDougall and Venkatesh, 2010; Iqbal and Bailey, 2005), and/or the participant is instructed to respond in a particular way (Altmann and Trafton, 2002; Czerwinski *et al.*, 2000; Eyrolle and Cellier, 2000; McFarlane, 2002; Trafton *et al.*, 2003). The subsequent impact on task performance and well-being is almost unvaryingly negative (Bailey, Konstan and Carlis, 2000; 2001; Jackson, Dawson and Wilson, 2003, McFarlane and Latorella, 2002; Zohar, 1999), with researchers concluding that interruptions are disruptive and should be limited in the workplace (Iqbal and Bailey, 2005; Jackson, Dawson and Wilson, 2001; Morgan, Patrick, Waldron, King and Patrick, 2009).

In this paper we focus on explicating CMC interruptions, over which workers have different levels of control, using Action Regulation Theory (ART: Frese and Zapf, 1994; Hacker, 1994), to frame understanding. ART states that when people have control over their work activity, they tend to execute actions that allow them to optimize their valued work and well-being goals. According to ART, control is defined as being able to impact conditions or activities at different ‘decision points’ or ‘phases’ within goal-directed work, and optimization involves working in the most efficient way, such that minimal resources are expended to achieve maximum gains (Frese and Zapf, 1994). This is important. A mainstay

of psychological theory is that when people have low control over work then well-being and performance suffers (Carver and Scheier, 1990; Hackman and Oldham, 1976; Karasek, 1979). In the 'real world', people receive or deal with many work interruptions (McFarlane and Latorella, 2002; Mark, Voida and Cardello, 2012), and have differing levels of control over these. Should the degree of control that one has over an interruption be examined, it is likely that the impact of an interruption on people's work will differ. Indeed, in the 'real-world', we continue to allow work interruptions to enter both home and workspace, despite their widely reported damaging effects (Chen and Karahanna, 2018). In many cases, we actively keep our notifications switched on, and often choose to respond to CMC interruptions immediately (Russell, Woods and Banks, 2017; Jackson *et al.*, 2003; McFarlane, 2002). Contrary to the primarily negative consequences of dealing with interruptions, noted in the extensive interruptions research literature (Addas and Pinsonneault, 2018), it is apparent that real-world interruptions to one's work can have positive benefits – boosting mood, assisting with the completion of tasks, providing opportunities to reprioritize, etc. (Sasangohar, Donmez, Trbovich, and Easty., 2012; Walji, Brixey, Johnson-Throop, and Zhang, 2004).

From an ART perspective, we propose that the concept of control might (after controlling for parameters of complexity, delivery mode, incurrence of cognitive demands, impact on mood etc.: Bogunovich and Salvucci, 2011; Turner, Allen and Whitaker, 2015) provide an explanation for the differently positive and negative impact of CMC interruptions on work performance. Examining different levels of control over interruptions potentially extends understanding as to why CMC interruptions continue to infuse our work, but also extends understanding regarding which types of CMC interruptions will be more or less disruptive in terms of impact – important knowledge for work designers and decision makers.

In this research, by focusing on the concept of 'control' as a delineator of interruption 'type', we make 3 contributions to the field of interruptions research. Firstly, by using the principles of ART, we examine 'control' at various decision points during the delivery of an interruption to distinguish how level of control influences CMC interruption response and outcome. This expands on previous research regarding how control influences the delivery (McFarlane, 2002) and reaction speed to an interruption (Bogunovich and Salvucci, 2011; Russell *et al.*, 2017; Turner, Allen and Whittaker, 2017). In this research, we uniquely suggest that decision latitude can be exerted at three phases within the interruption timeline (Trafton *et. al.,* 2003) and classify four types of CMC interruption, depending on the extent to which one has control over activity at each point. Secondly, we provide a precise definition of what we mean by a CMC interruption, and expound four constituent conditions. These conditions are amalgamations of definitions provided elsewhere (van den Berg, Roe, Zijlstra and Krediet, 1996; Speier, Vessey and Valacich, 2003; Sasangohar *et al.*, 2012), and enable us to clarify what does and does not (e.g. distractions, sequential task processing, ruminations, self-generated interruptions) constitute a CMC interruption episode (Adler and Benbunan-Fich, 2013; Jett and George, 2003; Salvucci, Taatgen and Borst, 2009). Our third contribution brings together the literature on task switching and interruptibility. After accounting for contextual, task, interruption and personal factors (Salvucci *et al.*, 2009; Turner *et al.*, 2015), which influence decisions made at each of the three phases where control might be applied, we suggest that relative disruptiveness of CMC interruptions can be predicted. A summary of research is provided relating to these factors in this paper, whilst acknowledging that an in-depth discussion goes beyond the aims of the present paper (and is dealt with elsewhere – e.g. Miller, 2002).

Our primary aim in this paper is to demonstrate that by advancing understanding of how control influences action during phases within the interruption timeline, we can better

appreciate how CMC interruptions affect our work performance in authentic work contexts. As a result of these contributions we anticipate that future research can compare and contrast the impact of different CMC interruptions in real-world work. This research allows managers and designers to consider whether more control can be provided at each phase in the interruption timeline so that the potentially deleterious effects of CMC interruptions at work be reduced.

To achieve our research aim, we begin with a review of the historical literature on work interruptions and what this has told us about the relatively disruptive effects of interruptions to work. We go on to discuss how this work informs understanding of real-world CMC interruptions and present our definition of a CMC interruption according to the satisfaction of four conditions. At this point, we discuss how control over interruptions at different phases in the interruption timeline can influence how disruptive a CMC interruption is, considering how different parameters influence decisions at different phases when control is present. Finally, we provide a working taxonomy of CMC interruptions, differentiated according to control at each of the three phases. To develop and progress understanding of CMC interruptions in research and practice we then present two propositions in our Discussion.

Historical Studies of Interruptions to Work

Within the prevailing literature, work interruptions have been conceptualized in many different ways (see Sasangohar *et al.*, 2012 for a summary), and so the historical body of research that discusses interruptions does not always come from the same point of reference. For example, distractions, self-generated interruptions, ruminations, daydreaming and task-switching, have been included or excluded in studies, depending on the researchers' personal definitions. We provide our classification of a CMC interruption later in this paper. However, to provide a generic signpost in reviewing the historic body of evidence, we summarize that

an *interruption* involves an externally generated incident being delivered at an unpredictable point in time, requiring recipients to turn their attention from an ongoing current task (however briefly) in order to execute another action or task (van den Berg *et. al.*, 1996; Speier *et al.*, 2003).

The field of study into interruptions is over 90-years old, initiated by Zeigarnik (1927) (as cited in Gillie and Broadbent, 1989) who concluded that interrupted tasks are more likely to be remembered (because mental closure of the task has not been achieved). Subsequent to Zeigarnik's seminal work, two approaches to studying interruptions within the research literature appear to have emerged. One approach is top-down and theory-driven. Here, cognitive processes are the focus, and interruptions are the tools used to examine individual responses at the point of interruption (Eyrolle and Cellier, 2000; Gillie and Broadbent, 1989; Morgan *et al.*, 2009; Roe, van den Berg, Zijlstra, Schalk, Taillieu, and van der Wielen, 1995; Zijlstra, Roe, Leonova, and Krediet, 1999). In simple terms, an interruption demands use of a finite set of cognitive resources that have already been allocated to the interrupted task. In the most part, when interruptions are demanding or complex (require more attention and memory reserves), similar to the task being interrupted (utilize processing modes already engaged), occur at a specific point in the interrupted task (when attention is more acute), or are unfamiliar (require more attention and memory reserves), then they will be especially disruptive (Miller, 2002). However, results are not consistent across the domain, indicating that these characteristics are not conclusively predictive in understanding how interruptions impact performance. For example, interruption complexity appears to be disruptive in many studies (Burmistrov and Leonova, 2003; Speier *et al.*, 2003) but not all (Cutrell, Czerwinski and Horvitz, 2001; Czerwinski *et al.*, 2000). In other studies, interruptions are found to be more disruptive at the start of a task, in others, at the end of the task (Cutrell *et al.*, 2001). Similarity between the interruption and the interrupted task can improve performance on

some occasions, whereas it can also be detrimental (Gillie and Broadbent, 1989). From this research we know that the demands afforded by the ongoing task and the interruption appear to impact with people's available resources and priorities to influence interruptibility and performance. However, interruptions research is ongoing in terms of finding explanations that can consistently predict when, why and how these factors interact.

The other approach is bottom-up and practical. This takes the interruption as the point of interest, with studies designed to establish how their presence in the workplace and daily life affects one's ability to achieve one's goals (Bailey *et al.*, 2001; Brumby, Cox, Back and Gould, 2013; Cutrell *et al.*, 2001; Czerwinski, Horvitz, and Wilhite, 2004; Czerwinski, Cutrell, and Horvitz, 2000; Einstein, McDaniel, Williford, Pagan, and Dismukes, 2003; Fishbach, Friedman, and Kruglanski, 2003; McFarlane, 2002; Speier *et al.*, 2003; Trafton *et al.,* 2003). This approach fits well with the ethos of the ART, which highlights that in order to understand the reductionist factors involved in people's actions and responses at work, researchers need to study 'complete activity' (involving personal goals and priorities) (Frese and Zapf, 1994), alongside features of the individual (Frese, Stewart and Hannover, 1987) and the current context (Zijlstra *et al.*, 1999). Yet, in existing studies of interruptions and goals, research oscillates between field, simulation, and lab-based approaches, meaning that either ecological validity via the examination of 'complete activity' (Einstein *et al.*, 2003; Morgan *et al.*, 2009), or control over isolated variables (Grundgeiger *et al.*, 2010; Mark, Gonzalez and Harris, 2005; Westbrook, Coiera, Dunsmir, Brown, Kelk, Paolini and Tran, 2010), may be compromised in generalizing results.

Whichever approach is followed there are two main conclusions. The first (rarer) conclusion suggests that interruptions are beneficial to one's work as: they can (i) help people to achieve their goals faster (Robertson, 2003) as subsidiary activity is eliminated when time pressures are introduced (Fishbach *et al.*, 2003; Zijlstra *et al.*, 1999); (ii) they increase

activation in undemanding situations (Fisher, 1998; Speier *et al.*, 2003); and, (iii) they provide a natural break (Jett and George, 2003), which can bolster resources (Sonnentag and Zijlstra, 2006). The second, and far more prevalent conclusion (Jackson *et al.,* 2001; Morgan *et al.*, 2009; Walji *et al.*, 2004), is that interruptions are highly disruptive because: (i) they force people to switch attention between tasks, which can be demanding and time consuming (Altmann and Trafton, 2002; Czerwinski *et al.*, 2000; Eyrolle and Cellier, 2000; Trafton *et al.*, 2003); (ii) they induce decay in the memory for the interrupted task (Altmann and Trafton, 2002; Czerwinski *et al.*, 2004; Einstein *et al.*, 2003; Morgan *et al.*, 2009); (iii) they cause people to spend longer on their work and/or commit more errors (Bailey *et al.*, 2001; Brumby *et al.*, 2013; Speier *et al.*, 2003); (iv) they induce anxiety, annoyance or feelings of being under time pressure (Baethge and Rigotti, 2013; Bailey *et al.*, 2001; Zohar, 1999); and, (v) they encourage perception that an interrupted task is more difficult (Bailey *et al.*, 2001; Czerwinski *et al*, 2004).

The prevailing concept that interruptions are primarily negative – stressors or hassles that are a hindrance to task goal achievement (Bailey *et al.,* 2000,) – is problematic, when applied to CMC interruptions, because these are not equivalent in their constitution. For example, a voicemail alert is not as disruptive as a computer crashing; however both can be considered to be interruptions. In addition, in authentic work environments, many CMC interruptions (e.g. email, skype calls, Instant Messenger) afford tasks in their own right (Walji *et al.*, 2004), and so their presence may be welcomed or needed, in the pursuit of goals, rather than resisted (Addas and Pinsonneault, 2018). To understand whether CMC interruptions are disruptive to workers, we consider them as potentially controllable tasks, that invite a strategic response in the context of one's complete activity – a key concern of ART – yet overlooked in the interruptions literature to date (Grandhi and Jones, 2015; Wickens, Gutzwiller and Santamaria, 2015). The conclusions of the extant research that a

blanket 'ban' or limitation approach should be pursued in order to effectively deal with interruptions (Morgan *et al.*, 2009; Jackson *et al.*, 2001), is – we believe - rarely realistic or consistently evidenced given the contemporary prevalence of CMC interruptions in modern working life. Below, we therefore outline the constitution of a CMC interruption, in order to progress study within this domain.

Examining Interruptions from a CMC Perspective

To address the impact of CMC interruptions on work activity, we provide a clear, overarching operational definition below, whereby four conditions must be met in order for an event to be considered a CMC 'interruption'. We then differentiate four 'types' of CMC interruptions, which are delineated according to the extent to which workers can control their response at three phases in the interruption lag of the interruptions timeline (Trafton *et al.*, 2003). This allows for the presentation of a 'taxonomy' of CMC interruptions. Each interruption classification is discussed by presenting empirical and CMC-specific illustrative evidence, indicating how control differentiates each 'type'. We then explain how this taxonomy can act as a framework for the classification and study of CMC interruptions in authentic settings, ensuring that conclusions made about the relative disruptiveness of interruptions is grounded in findings relevant to complete activity in real-world work.

Conditions of a CMC Interruption

We conceptualize a CMC interruption to one's work as - an electronically generated communication, which alerts the recipient to its presence at an unpredictable point during the execution of an ongoing work activity, and which requires the recipient to execute another task or action in relation to the incoming communication. Within this operational definition are four conditions that must be met in full (Turner *et al.*, 2017), to warrant a classification:

1. The interruption's point of delivery is unpredictable (even if workers expect to be interrupted at some point).

2. The interruption is electronically generated externally to the recipient, and its presence is usually announced via some form of alert or notification.
3. The interruption occurs when the individual is already engaged in an ongoing work activity (to which the CMC may or may not be related).
4. The interruption affords a task/action of its own (i.e. it requires the recipient to do something or change something).

Some electronically-generated 'interruptions' studied in the literature to date would not be classified as interruptions in the present framework, as they do not comply with all four conditions. For example, internally generated events (e.g. setting a calendar alarm to notify of an appointment at midday, or choosing to have a flick through one's social media feed) would not be classed as a CMC interruption (Baethge *et al.*, 2015), as this contravenes conditions 1 and 2. This differentiates our definition from those made by Sasangohar *et al.* (2012) and Jett and George (2003). In addition, if one cannot anticipate the exact moment of an interruption's arrival (even if one is operating in an interruption-rich environment, where interruptions are to be expected), then the event will constitute an interruption, as long as it occurs whilst one is currently undertaking other, ongoing work activity. This means that an individual who stops work to await an important email would not be dealing with an interruption, because waiting for the email becomes their current and planned activity, contravening condition 3 (and differentiating our criteria from categories put forward by McFarlane, 2002).

Further, 'distractions' are often considered to be a form of interruption (Jett and George, 2003; Mark *et al.*, 2005) because they compete for attentional and memory resources (Wickens and Hollands, 2000). However, because they do not afford an action, distractions do not have the potential to be a full interruption because they do not adhere to condition 4. The notion as to whether an interruption is fully fulfilled is an interesting one to consider in

clarifying our definition. For example, Turner at al. (2017) recently found that in many cases an interruption will be ignored or abandoned at different points in its lifespan. As we are interested in people's decisions regarding their interruptions, we take heed of such research and acknowledge that an interruption may be partially attended to and then dropped (i.e. the recipient may begin to deal with it but then decide to leave it) (Turner et al, 2017). However, we stipulate that a CMC interruption must afford a task or an action that must be attended to *at some point*. This means that even if it is temporarily ignored or abandoned, the recipient must come back to it eventually – even if that is only to nullify or delete the task in some way. This further exemplifies why a distraction would not be considered an interruption, but emphasizes that when one has control over incoming CMC interruptions, one's actions can be adapted and selected according to one's current work and well-being goals, to be picked up or delayed accordingly.

In the next section we present the three phases within the interruption lag in the interruption timeline (Trafton *et al.*, 2003) where control may or may not be exerted. At each phase, when control is available, the recipient can make a decision regarding how to deal with the CMC interruption, in the context of their current goals and activities.

Control Points in the Interruption Lag

The interruption lag is the time period elapsing between receiving an interruption alert (the point of delivery) and attending to the secondary (interrupting) activity (Trafton *et al.*, 2003). During this lag, the current, ongoing task can be temporarily suspended and primed for future retrieval before the task/action afforded by the interruption is oriented towards and its goal activated (Altmann and Trafton, 2002). In this paper, three phases in the interruption lag, where one's response to a CMC interruption can be controlled, are identified for the first time. In each phase, if the worker has control over what to do, then they have decision

latitude over when, whether and how to act on the interruption, and this depends on the aforementioned contextual, personal, task and interruption characteristics, see Figure 1.

[*Insert Figure 1 about here*]

In phase one of receiving a CMC interruption the individual will be notified, e.g. by a sound or vibration from a mobile phone. At this point, if the individual has decision latitude, they can decide to deal with the notification and move onto the next phase, or decide to ignore it and resume their interrupted activity. In the second phase, assuming control, the individual will choose whether to check the contents/requirements of the interruption; for example, the individual decides to read the incoming text message. Again, at this point they may then transition to phase 3, or return to their interrupted activity. If the recipient moves to phase 3 then, assuming control, they will decide what to do in relation to the task/action afforded by the interruption.

To illustrate the meeting of all four conditions and the interaction with the three phases of control, consider an IT employee working on the IT Help Desk. Their role is to physically repair computers whilst answering help requests via email and telephone. The IT worker expects to be dealing with interruptions but the actual moment of the delivery of a CMC interruption cannot be predicted and is outside of their control (satisfying conditions 1 and 2). The worker is usually repairing computers or dealing with existing help requests (satisfying condition 3), when they might be alerted to the presence of a new help request via email (satisfying condition 4). Help request alerts must remain 'on' at all times as a requirement of their job, but the worker may choose not to look at the request at that point (i.e. decision latitude at phase 1). For example, if the IT worker is currently dealing with another customer face-to-face then they will feel obliged to ignore the interruption for the time being (even though they will have to attend to it at some point). When convenient, the worker will check the incoming alert, and at that point it is allocated to them as a task and it

is a requirement of the job to deal with it, usually according to strict procedures or scripts (no control at phase 2 or 3). In summary, all four conditions must be met for the incoming email help request to be classified as an interruption and there are three interrupt phases during the time lag that outline the decision making process:

Phase 1: an alert is received; decision – when and whether to check

Phase 2: check the interruption; decision – when to deal with it

Phase 3: deal with the interruption; decision –whether and how to deal with it.

At each phase, a range of factors will influence the decision one makes about when, whether and how to deal with or ignore the interruption, For example, if one is involved in searching for information at the point when an interruption is presented then, assuming control, one is highly likely to ignore the interruption at phase 1 (Turner *et al.*, 2015). At phase 2, the high status of the sender, or one's currently bored mood state is more likely to prompt the recipient to decide that the interruption should be dealt with there and then (Russell, Purvis and Banks, 2007). At phase 3, the recipient may take a long time dealing with the interruption, if it is of high importance, or they need a break (Jett and George, 2003; Wickens and Hollands, 2000; Wickens *et al.*, 2015).

In some studies, reported in this paper, there is no interruption lag as the worker is forcibly taken from their interrupted task to the interrupting task (as in: Eyrolle and Cellier, 2000; Gillie and Broadbent, 1989; Speier *et al.*, 2003) and cannot control their response at either phase 1 or phase 2 (Figure 1). In other studies, the worker has control over attending to the interruption alert at phase 1 (Fisher, 1998; Katz, 1995; van Solingen, Berghout and van Latum, 1998; Zijlstra *et al.*, 1999), and in terms of checking the interruption at phase 2 (Carton and Aiello, 2009; Katz, 1995; McFarlane, 2002; Zijlstra *et al.*, 1999) whereby they may put the interrupting task to one side temporarily (phase 3) if the interruption is less

important than the current (interrupted) task (Colligan and Bass, 2012; Grundgeiger *et al.*, 2010; Jackson *et al.*, 2003).

Whether the worker has control at each phase appears to be a consistent delineator with regards to how disruptive interruptions reported in the literature appear to be. In the studies reported above, when recipients have increasing control over an interruption (e.g. in all three phases) they also have increasing agency over what checking and/or response strategy to implement (Grandhi and Jones, 2015; Russell *et al.*, 2007; Russell *et al.*, 2017*).* ART specifically considers – using principles of behavioral economy - that when workers have control over their work, they will choose strategies that optimize performance (Frese and Sabini, 1985; Frese and Zapf, 1994; Schönpflug, 1983). Having control within the interruption lag is important as it is in the interruption lag that the recipient can choose actions to close down or suspend their interrupted task before attending to the new task. Workers can also use the lag to prepare the interrupted task for later resumption, thus eliminating some of the memory recall problems and task errors that occur when one attempts to return to an interrupted task (Altmann and Trafton, 2002).

When one does *not* have control in the interruption lag this can cause people to make mistakes (Gillie and Broadbent, 1989) and experience stress or reduced well-being (Cohen, 1980; McFarlane and Latorella, 2002). In ART terms, this appears to be because the recipient cannot implement their own action choices (Frese and Zapf, 1994) to deal with the interruption (Latorella, 1996, 1998). The need for autonomy and decision latitude is a basic human need (Deci and Ryan, 2008), such that in studies where there is no 'designed for' interruption lag, people will try to exert control here anyway by attempting to apply their own strategies to optimize efficient working (Burmistrov and Leonova, 1996; Zijlstra *et al.*, 1999).

By examining control at three phases in the interruption lag, we have identified four key 'types' of CMC interruption, over which workers have different levels of control at

different phases: Enforced Interruptions (no control), Critical Response Interruptions (control at phase 1), Synchronous Controlled Interruptions (control at phases 1 and 2) and Asynchronous Controlled Interruptions (control at phases 1, 2 and 3). These are outlined now below, with supporting empirical evidence and illustrative examples from the CMC domain. As each type of interruption increases in terms of 'controllability' (from no control to full control), the relative disruptiveness of that CMC interruption decreases.

Four Types of CMC Interruption: a Taxonomy

1. Enforced Intrusions.

In this type of interruption there is no recipient control at phases 1, 2 or 3 (Figure 2a), as the interruption is forced upon the worker, and the recipient must provide an immediate response. For example, a customer services operator, working in an insurance agency, is processing a claim form on their desktop computer when the screen clears and an alert is presented – you must attend to the incoming call within a few seconds (in line with company policy). No warning is given and the worker has been forced to disengage from the claim processing task (which cannot now be accessed). The worker must click on the alert and deal with the caller immediately. Enforced intrusions are likely to be the most disruptive type, because the worker's level of control is so diminished and the interruption lag is effectively nullified (Eyrolle and Cellier, 2000; Morgan *et al.*, 2009).

Intrusions have been identified as a special type of interruption in the literature (Jett and George, 2003). However, the decision about when and whether to check an intrusion has been previously classed as being under the control of the recipient (Jett and George, 2003). This is where the present definition differs. In this paper it is stated that an Enforced Intrusion is an interruption that is forced upon the individual; the lack of control at phase 1 making it constitutionally different to other interruptions. This can be exemplified in a study by Altmann, Trafton and Hambrick (2014). In their lab-based experiments, participants were

engaged in a sequential processing task on a computer. At different points in the sequence an interruption task was presented on the computer screen with no warning. Participants had no control over the delivery of the interruption or its task. In both the shorter (2.8 seconds) and longer (4.4 seconds) interruption conditions, errors to the interrupted task were significantly higher than baseline. The flow of mechanisms involved in attention and working memory were stymied, because of the lack of control at any stage in the interruption lag (Altmann *et al.*, 2014), causing the disruption. Figure 2a demonstrates the delivery of an Enforced Intrusion, using the example of a customer services operator.

[*Insert Figure 2a about here*]

2. Critical Response Interruptions.

These interruptions are usually expected features of certain working environments. However, to constitute an interruption, the arrival of the alert needs to be beyond the control of the recipient and its timing cannot be predicted. After this point, the recipient has a level of control over how long they take to check the interruption (at phase 1) but it is critical that recipients do not delay checking for long and, once checked, the interrupting task must be attended to immediately (no control at phase 2 and 3). Critical Response Interruptions might include pager alerts to healthcare professionals (e.g. ICU audible and visual (text) alarm to indicate the patient has stopped breathing: Walji *et al.*, 2004). The recipient may quickly finish what they are doing (control at phase 1) but then attend to the interruption requirements without delay, e.g. by attending to the patient who triggered the alert.

Despite the multitude of studies of interruptions within the aviation, healthcare and 'emergency' response industries, very few have actually examined the Critical Response Interruption. Most of the studies are focused on examining how Enforced Intrusions or Controllable Interruptions have a negative and sometimes fatal impact on critical role holders' ability to execute essential tasks (Dismukes, 2012; Grundgeiger *et al.*, 2010;

Westbrook *et al.*, 2010). Kirmeyer (1988), describe 'pre-emptive' interruptions to police call handlers that – once checked – required the handler to deal immediately with the interrupting task. Kirmeyer's study found that when these Critical Response Interruptions were more frequent, perceptions of overload increased. Apart from this study, there is a real dearth of evidence to suggest to what extent a Critical Response Interruption is disruptive.

This appears to be something of an oversight. For example, whilst Dismukes (2012) firmly concludes that interruptions and distractions are highly disruptive and can cause fatal errors in important jobs (such as airline industry), in the same paper, Dismukes discusses a Critical Response Interruption that reminded pilots to set airplane wing-flaps to the correct position before take-off, averting a catastrophe. Without *this* critical response type of interruption, the consequences could have been extremely damaging. Chisholm, Dornfeld, Nelson and Cordell (2001) acknowledge (but do not study) Critical Response Interruptions (specifically with regard to 'care' or 'patient' interruptions) in their study of Clinicians, and highlight how such interruptions must be allowed in these job roles, to offset potentially dire consequences. This further supports the proposition that interruptions be delineated according to type, and that assumptions that different types of interruption are equivalent in their disruptiveness to work cannot be made (Sasangohar *et al.*, 2012). Figure 2b demonstrates the delivery of a Critical Response Interruption, using the example of a healthcare professional being paged.

[*Insert Figure 2b about here*]

3. Synchronous Controllable Interruptions.

Controllable interruptions give the recipient control over when to check the interruption alert at phase 1. However, at this point relative control over the interruption differs according to the synchronicity requirements of the interruption. A 'synchronous' controllable interruption requires communication in real-time (e.g. a telephone or skype call).

An ‘asynchronous’ controllable interruption does not (e.g. an incoming email or voicemail). We will firstly deal with Synchronous Controllable Interruptions.

Once the recipient has decided to pick up the ringing telephone (control at phase 1), for example, the recipient finds out what the call is about and who it is from. They then have some control over when to deal with the interruption at phase 2 (potentially asking the instigator if they can call them back in five minutes). However, because etiquette in human behavior would usually dictate that once an alert has been responded to (e.g. the phone has been picked up) the interruption should be accepted, negotiating one’s response with another time-present person expecting a time-present response, reduces the extent to which workers have control over decisions to act at phase 2 and 3 (Rennecker and Godwin, 2005; McFarlane and Latorella, 2002).

Decisions made in phase 1 and phase 2 of dealing with a Synchronous Controllable Interruption are likely to depend on the factors outlined in Figure 1 (Fisher, 1998; van den Berg *et al.*, 1996; Zijlstra *et al.*, 1999). For example, some people will delay attending to the interruption at phase 1 (e.g. ignore the phone ringing, or skype alert) when current demands are high (Katz, 1995). Once checked (phase 2), the interruption task may be rejected (e.g. “sorry I can’t talk right now”) if the call is low priority or from someone of low status. Decisions about whether to delay transitioning to phase 3 will usually depend on the recipient weighing up the relative priority of the interrupting task with their interrupted task (Miller, 2002). In selecting one’s action response, ART states that workers weigh up parameters of the situation to select a strategy that has been efficient in the past (Frese and Zapf, 1994; Hacker, 1994). Pertinent parameters at phases 1 and 2 (see Figure 1) include the status of the instigator of the interruption, the personality/mood of the recipient, and the extent to which the interruption and interrupted event are expected to fulfil different work and well-being goals (Grandhi and Jones, 2015; Hockey, 2000; 2002; Louro, Pieters and Zeelenberg, 2007;

Rennecker and Godwin, 2005; Zijlstra *et al.*, 1999). In moving this field forward it will be useful for researchers to examine how different parameters specifically impact controlled choices at phase 1 and 2. Due to the time-present expectation of response, control at phase 2 is lower in synchronous interruptions (as explained above), but under the full control of the recipient in asynchronous interruptions. Figure 2c demonstrates the delivery of a Synchronous Controllable Interruption, using the example of a skype call.

[*Insert Figure 2c about here*]

4. Controllable Asynchronous Interruptions.

These interruptions do not require that the recipient respond immediately to an interruption alert (at phase 1) and the recipient also has full control over whether to delay at phase 2. This is because Controllable Asynchronous Interruptions do not engage the recipient in a real-time exchange with another time-present person. As such, after checking the interruption alert (phase 2) there is no synchronous sense of pressure to attend and respond immediately (Rennecker and Godwin, 2005) because the sender does not know whether you have received the interruption in present time or not. Controllable Asynchronous Interruptions might include email interruptions or voicemail alerts, where the recipient can control how much time elapses between alert and checking, and before they respond to the interruption (i.e. accept the task or activity). Once checked, there is decision latitude at phase 3 over whether to deal with the interruption (e.g. the email), and how long to spend dealing with it. The interruption episode for Controllable Asynchronous Interruptions can therefore be quite lengthy and will depend on how respectively important the primary and secondary (interruption) tasks are (Belotti, Ducheneaut, Howard, Smith, and Grinter, 2005; Dabbish, Kraut, Fussell and Kiesler, 2005). Parameters that influence decisions (and therefore the duration of the interruption episode) include: individual features such as current mood and personality (Colligan and Bass, 2012; Fishbach *et al.*, 2003), task features such as demands

and valence (van Solingen *et al.*, 1998), and organizational features such as culture and policy (Barley, Meyerson and Grodal, 2011; Derks and Bakker, 2012). These elements will feature in decisions about when, whether and how to deal with the interruption across the three phases.

Controllable Asynchronous Interruptions are similar to those in McFarlane's (2002) 'negotiated' condition, but – in our terms - whether one wants to 'negotiate' a response must be under the participant's control. In van Solingen *et al.* (1998)'s research they found - in a field-based survey – that about 90% of interruptions were responded to immediately by workers who had control over their response, with the 10% that are delayed being put off because they were more complicated or arduous to deal with. Thus, when people have control over their interruptions, as is typical of a Controllable Asynchronous Interruption, they may still choose to deal with it immediately if this has goal-achieving benefits (Jackson *et al.*, 2003, McFarlane, 2002). This type of CMC interruption has the highest level of control for recipients, and indicates that with control comes the likelihood that strategic behavior will interact with people, organizational, task and interruption parameters in reducing disruptive effects (Carton and Aiello, 2009; Grandhi and Jones, 2015; Huang and Lin, 2014). Figure 2d demonstrates the delivery of a Controllable Asynchronous Interruption, using the example of an email.

[*Insert Figure 2d about here*]

Applying the Framework

By using control as the key distinguishing variable between interruption types, any type of CMC communication can be classified, using our framework. Classification depends on the level of control one has, rather than the actual mode or type of CMC. For example, Instant Messenger (IM) may sometimes be objectively classed as a Controllable Synchronous Interruption, and sometimes as an Controllable Asynchronous Interruption, depending on

how it is set up – i.e. depending on the level of control allowed in phases 1-3 (see Figure 1) in individual workplaces and for individual users (Ou and Davison, 2011). If a sender can see that the recipient is 'available' on IM, then the recipient will be under pressure to respond in real time, making this a Synchronous Controllable Interruption. If the recipient has not set up IM to allow senders to see whether he or she is 'available' then there is no pressure to respond in real-time, as the recipient could easily be away from their computer or device, and so the interruption becomes a Controllable Asynchronous Interruption. Interestingly, empirical evidence shows that as control over IM increases (from synchronous to asynchronous formats) its disruptive effects reduce. A study by Bailey and Konstan (2006) found that when the recipient has control over when and whether to respond (at phases 2 and 3) in IM exchanges (asynchronous), there were fewer errors, less time taken to deal with the task, and lower levels of annoyance and anxiety, compared with a synchronous IM set up.

In line with the four general conditions needed to consider an event to be an interruption, this all-encompassing framework appears to capture all of the existing types of CMC interruption that are found in modern work environments. Using our framework, CMC interruptions are categorized objectively, according to the degree of control (in ART terms) that a person has over the interruption, during the three phases of the interruption lag in the Trafton *et al.* (2003) timeline. As such, as new CMC tools are developed, their interrupting effects can be appraised according to this approach, and categorization can be made explicit. Previous attempts to classify interruptions have relied on the subjective experience of the individual recipient of an interruption to determine its categorization. For example, in Jett and George's (2003) framework the same interruption may be considered to be a 'break' for some people, but an 'intrusion' for others, depending on the tasks they are engaged in and the tasks afforded by the interruption[i]. This can make it difficult to predict how an interruption is going

to impact on a person's performance until the researcher also knows how each individual has interpreted it (Zijlstra, 1993; Hockey, 2000).

Discussion and Implications

CMC interruptions are ubiquitous in modern working life. However, the extant literature on interruptions has primarily examined experimentally enforced interruptions to manipulated work tasks. This does not necessarily reflect the reality of dealing with CMC interruptions, such as skype, email and phone calls, in people's work – as there is often an element of control that can be exerted over dealing with these that previous research has not elucidated. Our framework explicates four conditions that constitute a CMC interruption and uniquely classifies CMC interruptions into four categories depending on the level of control a worker has over it at three phases in Trafton *et al*.'s (2003) interruption lag. Providing this framework enables researchers to determine whether a CMC event is actually an interruption, and how disruptive this is likely to be, depending on levels of control.

Our intention is that the field of research into real-world CMC interruptions can now be advanced by utilizing our framework. As such, we present two propositions to guide future studies and knowledge development.

The first proposition made to advance the study of CMC interruptions is therefore:

That an interruption event is objectively classified as one of the four types of interruption specified above, in terms of how controllable it is at three phases in the interruption lag, and whether it satisfies this framework's four conditions. This will ensure that:

a) *Conclusions made about the disruptive effects of a CMC interruption on work performance are only generalized to the type of interruption studied*
b) *There is conceptual clarity about whether an event is an interruption or something else – such as a distraction or a planned activity*

c) *Researchers from lab-based and field-based traditions can consider the extent to which their research findings are generalizable to other domains.*

The framework and outline review of the literature presented here suggests that the more control one has over an interruption, the less disruptive its effects are, as control allows recipients to manipulate the use of the interruption lag (Altmann *et al.*, 2014), choose strategies that are likely to optimize performance (Frese and Zapf, 1994; Hacker, 1994; Russell *et al.*, 2017) and reduces the strain experience (Carton and Aeillo, 2009; Grandhi and Jones, 2015; Russell *et al.*, 2007). Control is central to ART, as it is when workers have autonomy over their work – and therefore CMC interruptions – that they are able to more effectively regulate action to benefit goal achievement. As such, the second key proposition is:

That researchers evaluate the controllability of a CMC interruption and examine how control at the three phases in the Figure 1 timeline impact on the strategies chosen to deal with the interruption (in light of knowledge about existing parameters), and the relative disruptiveness of the interruption event on different goals.

Testing this proposition will allow research in CMC interruptions to advance by understanding how control may act as a moderator of the interruption-performance relationship, based on existing knowledge (stemming from empirical research undertaken in lab and field settings) regarding the influence of different parameters on decision making at the different phases.

[*Insert Figure 3 about here*]

To encourage the empirical testing of these propositions, and to utilize our framework of CMC interruptions, we present a flow-chart that allows researchers to categorize the CMC interruption used in their planned studies according to our classifications (see Figure 3). This flowchart can also be used by managers and designers to understand whether a CMC

interruption is likely to be more or less disruptive, depending on how much control can be exerted over its delivery and management. This is useful in appraising the disruptiveness of currently prevalent interruptions, but also in order to understand the likely impact of new CMC tools (with interrupting qualities) prior to their introduction.

Conclusions and Future Directions

To date interruptions research has been disparate and broad, data-rich and active. Studied by human systems designers, human-computer interaction researchers, cognitive and experimental psychologists, this lively field of research nevertheless lacks a unifying paradigm to amalgamate findings into a coherent and recognizable format. As such, managers and practitioners flounder when drawing on this research to make recommendations about how best to classify, evaluate and effectively manage CMC interruptions. In this paper we make three key contributions to progress understanding of how people deal with CMC interruptions, according to: (i) levels of control, uniquely expressed in terms of decision latitude in the interruption timeline; (ii) a clearly defined constitution of four types of CMC interruption; and, (iii) what the extant research on interruptions tells us about the parameters of task, interruption, person and contextual factors, and the respective influence of these on action at each phase

Current priorities within the research community have focused on building intelligent systems for managing interruptibility (e.g. Turner *et al.*, 2014). Defining the boundaries of interruptions, environments and objectives has been central to coordinating this focus. Our research addresses some of these issues by utilizing the extant research on interruptions to (i) better understand how CMC interruptions differently disrupt efficiency at work and (ii) aid the community by providing a unified interruptions framework that applies to the real-world. As such, when developers are designing new CMC systems, more detailed planning can be given to providing more control over the interruption to the end-user. Control over CMC

systems can positively impact users' working lives; if developers promote these control elements, this can start the educational cycle of the value of taking control of interruptions.

In summary, the framework provided in this paper offers a foundation of conceptual clarity in classifying CMC interruptions according to levels of control. Relatedly, the two key propositions suggest the optimal way forward to answering the next wave of research questions about CMC interrupted work. This should enable designers and researchers to be confident that the present framework has both a credible and broad research basis, whilst also being applicable to the complicated synchronized world of current and new CMC interruptions, as they continue to impact all of us at work.

Figure 1. Control phases during the interruption lag in the Trafton *et al.* (2003) task interruption and resumption timeline

Figure 2a. The timeline of an Enforced Intrusion, using the example of a severed server link

Figure 2b. The timeline of a Critical Response Interruption, using the example of a healthcare professional being paged

Figure 2c. The timeline of a Synchronous Controllable Interruption, using the example of a skype call

Figure 2d. The timeline of a Controllable Asynchronous Interruption, using the example of an email

Figure 3. Classifying a CMC interruption according to levels of control

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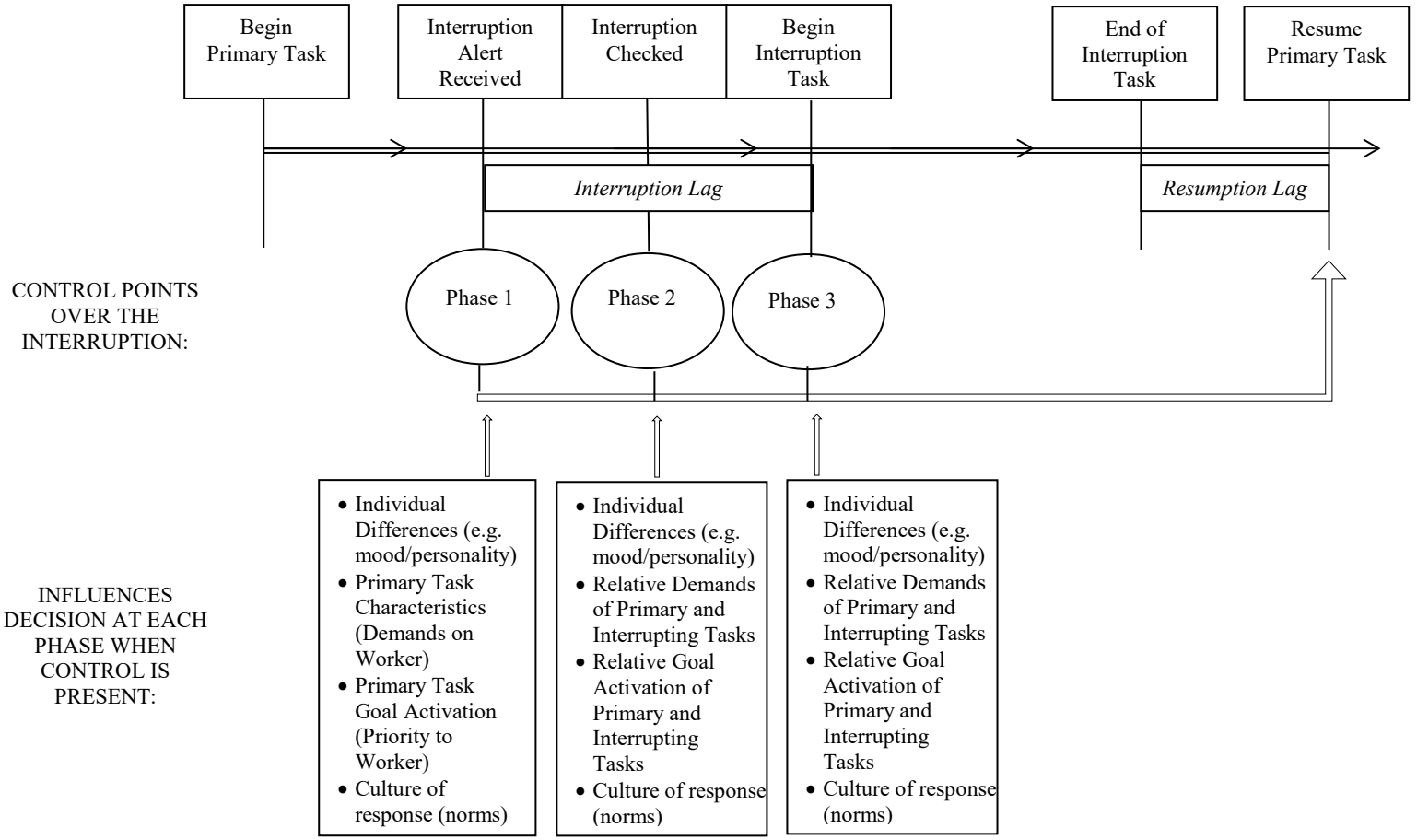
Figure 1. *Control points during the interruption lag in the Trafton et al. (2003) task interruption and resumption timeline*



N.B. the resumption lag is the period where the recipient of the interruption prepares to resume the interrupted task. Because this paper is concerned about control over the interruption itself (phases 1-3), this aspect of the original Trafton et al. (2003) timeline is not discussed.

Figure 2a. *Dealing with an Enforced Intrusion, using the example of a forced incoming call to customer services operator (IN CAPITALS)*

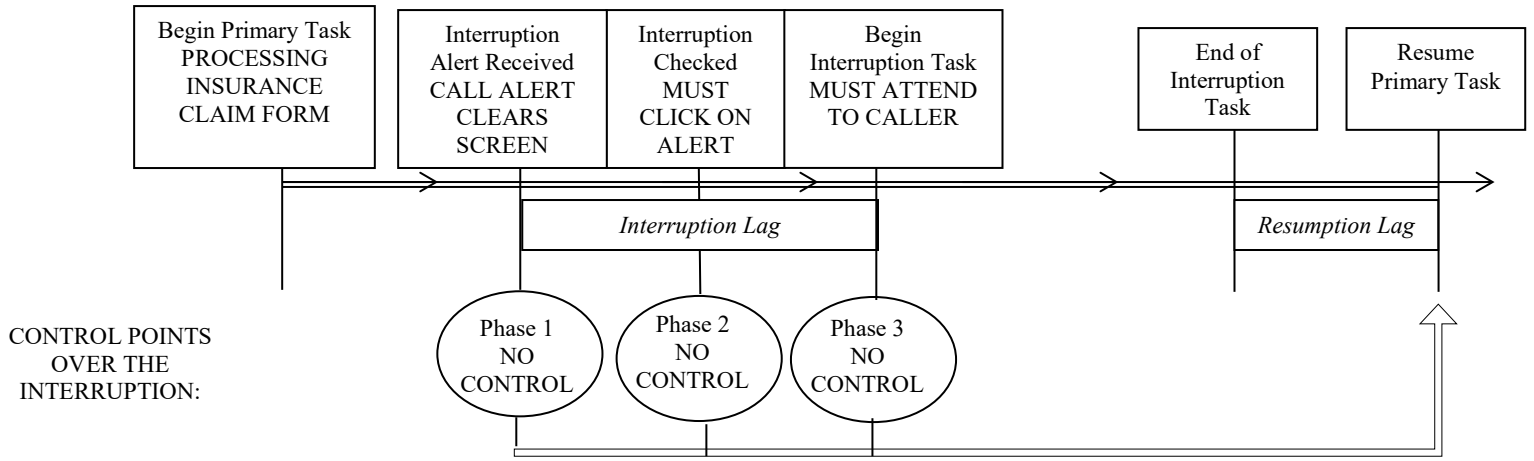


Figure 2b. *Dealing with a Critical Response Interruption, using the example of a healthcare professional being paged (IN CAPITALS)*

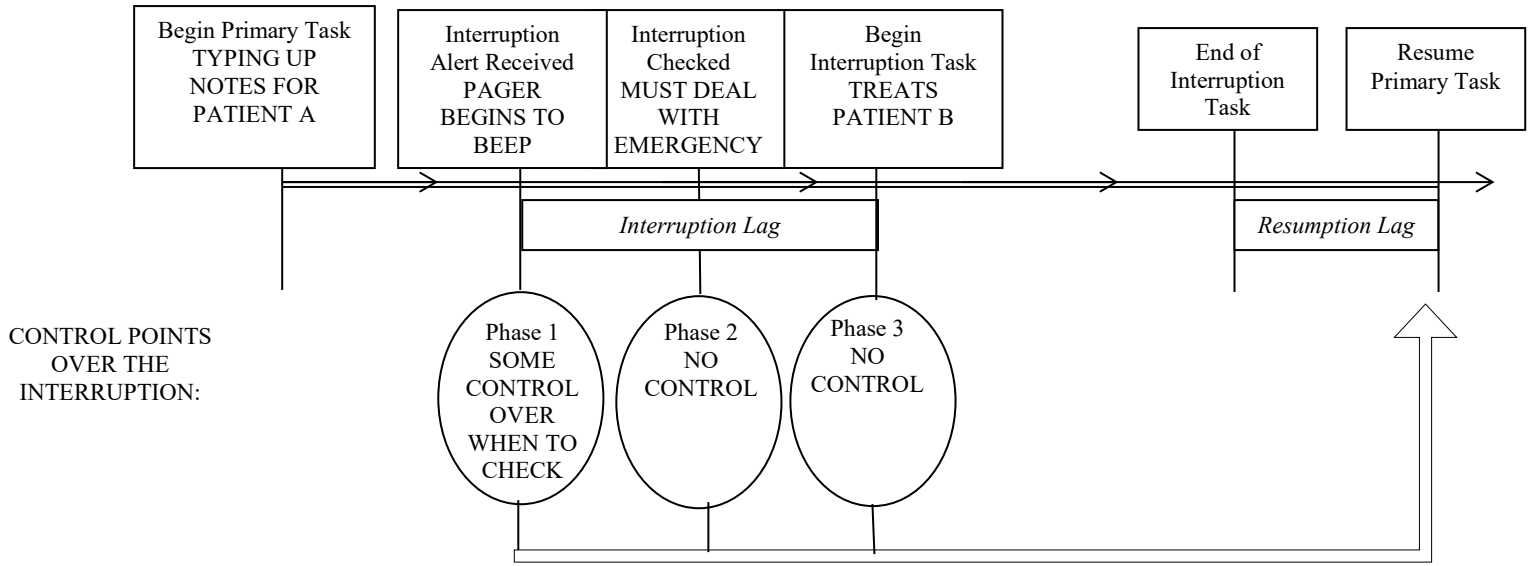


Figure 2c. *Dealing with a Synchronous Controllable Interruption, using the example of an office worker receiving a phone call (IN CAPITALS)*

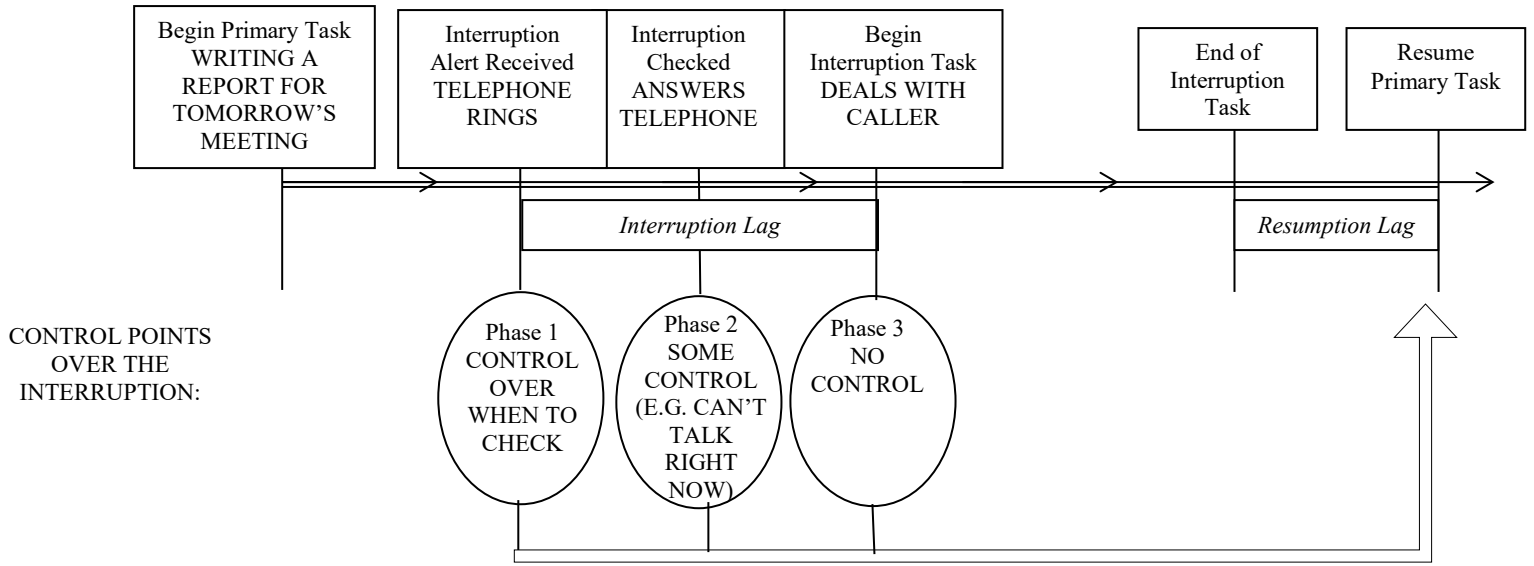


Figure 2d. *Dealing with an Asynchronous Controllable Interruption, using the example of an office worker receiving an email (IN CAPITALS)*

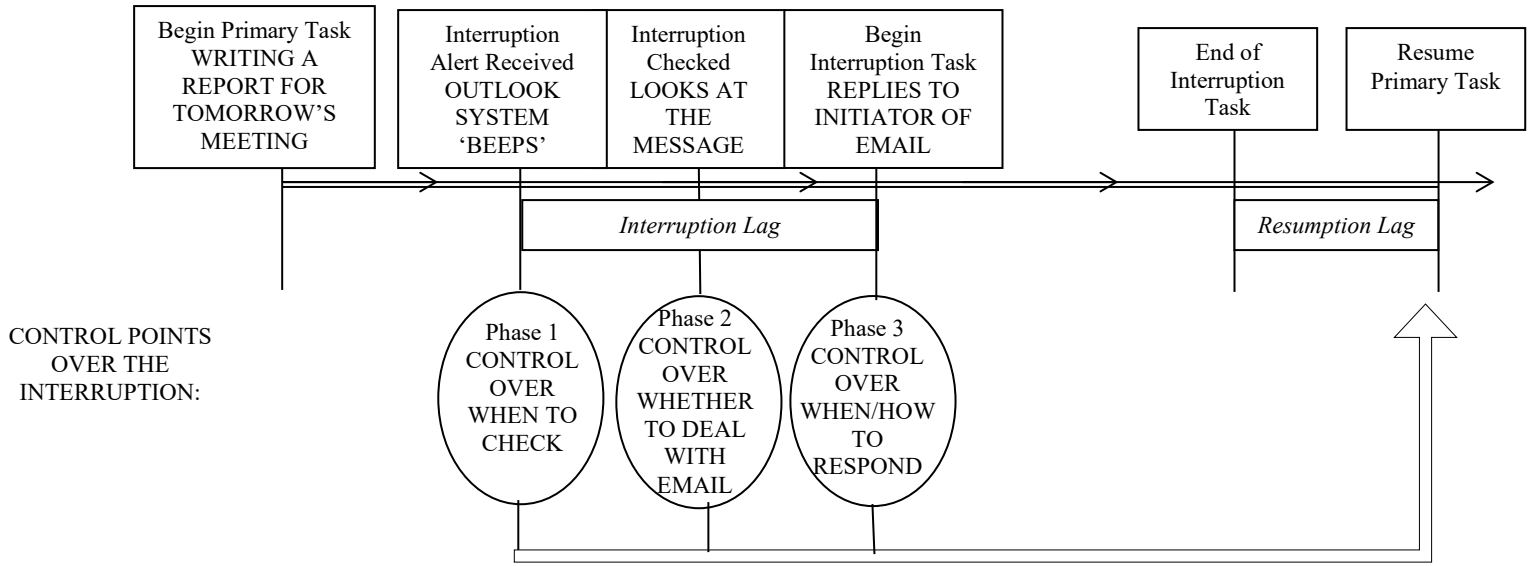
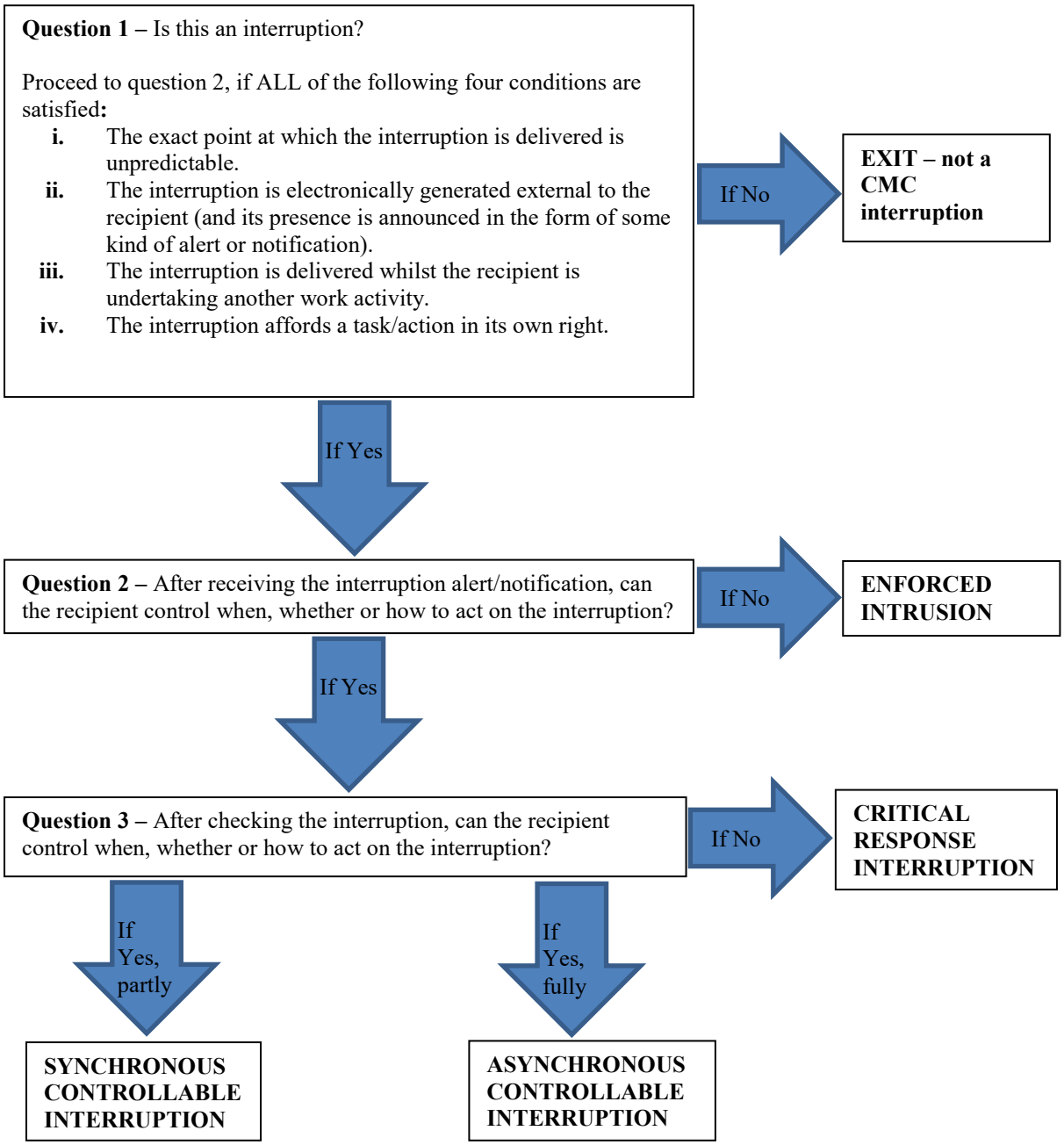


Figure 3. *Classifying a CMC interruption according to levels of control*



[i] It is likely that a person who uses interruptions to 'choose' to take a break, has some level of control over their work, and potentially sees an interruption as a positive entity in challenging work circumstances. It is worth acknowledging here that one's experience of interruptions (e.g. if one uses them as breaks, or if one experiences these as intrusions) could influence the extent to which one responds positively towards them or not. The accumulation of interruption experiences (Baethge et al., 2015), could therefore be another variable that interacts with control in influencing how interruptions impact work. We thank an anonymous reviewer for this suggestion.