

# Smartphone-size screens constrain cognitive access to video news stories

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*Abstract:* Smartphones are expanding *physical* access to news and political information by making access to the internet available to more people, at more times throughout the day, and in more locations than ever before. But how does the portability of smartphones—afforded by their small size—affect *cognitive* access to news? Specifically, how do smartphone-size screens constrain attentiveness and arousal? We investigate how mobile technology constrains cognitive engagement through a lab-experimental study of individuals' psychophysiological responses to network news on screens the size of a typical laptop computer, versus a typical smartphone. We explore heart rate variability, skin conductance levels, and the connection between skin conductance and the tone of news content. Results suggest lower levels of cognitive access to video news content on a mobile-sized screen, which has potentially important consequences for public attention to current affairs in an increasingly mobile media environment.

Researchers have long been interested in the societal implications of changes in communication technology. From the invention of the mass printing press (e.g. Hamilton, 2004) to the proliferation of social media (e.g. Bode, 2016), scholars have sought to understand the civic and democratic consequences of technological change, with a particular focus on questions about who has access to public affairs information, who seeks it, and who ultimately is exposed to it.

The next important frontier of change in communication technology is the shift to mobile. This fact is very clearly reflected in industry trends: more than 60% of Americans own smartphones, and an increasing proportion rely solely on their mobile devices for Internet access (Pew 2015; for related trends, see, e.g., Newman, Fletcher, Kalogeropoulos, Levy & Nielsen, 2017; Slefo, 2017; Molla, 2017; Pew 2016). Indeed, mobile use is so pervasive that the technology is sometimes credited with erasing lingering digital divides, helping so many to overcome the barrier of physical access to the Internet (Weidmann et al., 2016). Reports point to gains in access to the Internet among the young (Kim et al., 2007), those with lower incomes, those in rural settings (Burrell, 2010), and racial and ethnic minority groups (Pew 2016).

Improving physical access to the Internet certainly affords the possibility of more widespread exposure to public affairs information online, and recent work shows that high speed internet access facilitates seeking news online and gains in political knowledge (Lelkes, 2016). But are mobile devices the great leveler they are purported to be? There is a growing body of evidence suggesting that mobile-only access may not be sufficient for achieving these pro-civic outcomes. In fact, some researchers describe those who are dependent on mobile device for Internet access as an “emergent Internet underclass” or “second class digital citizens” (e.g., Mossberger et al., 2013; Napoli & Obar, 2014).

What accounts for these two conflicting expectations for the impact of mobile devices? One explanation is that research on mobile technology and democracy has yet to seriously consider the different ways in which mobile devices structure access to information. We aim to address this issue below by applying Grabe and colleagues' (2000) distinction between *physical* and *cognitive* access to the case of mobile news. Doing so helps explain divergent findings by highlighting how mobile expands access in some ways while also limiting it in others. It also situates studies of the impact of mobile more clearly in the context of media effects research. This is appropriate for three reasons: (1) this work has always tried to understand the implications of various communication technologies for media effects (e.g. Iyengar & Kinder, 1987; Stroud, 2011), (2) media effects research has often demonstrated that communication technologies constrain media effects through their impact on the tradeoff between breadth and depth of exposure (e.g. Prior, 2007), and (3) effects research shows that information processing is affected by both information content and information structure (e.g. Lombard & Ditton, 1997).

Put succinctly: even if it is the case that mobile technology facilitates widespread *physical* access to information, the constraints it imposes on *cognitive* access may make for a rather different information-seeking and processing experience. We consider this possibility below by examining whether cognitive access to online video news is attenuated when that video is viewed on a smartphone-sized screen. We rely on a lab experiment in which participants view video news stories, under either large- or small-screen conditions. Motivations to attend news stories vary greatly according to the characteristics of those stories, of course, so we also account for the potentially arousing nature of stories by coding them for positive and negative tone, and this sentiment coding is critical to one test of attentiveness, focused on the extent to which skin conductance varies alongside story tone. Conceptually, cognitive access refers to the ease with which information is processed upon exposure, making it an important precursor to important outcomes like learning and persuasion (Grabe et al., 2000). When defined operationally as either heart rate variability (HRV) or skin conductance levels (SCL), our findings suggest that screen size limits cognitive access to online video news.

The novelty of what follows lies not so much in the finding that screen size limits physiological responses to video, but rather in the application of the *physical-cognitive* access distinction to thinking about the impact of mobile technology, and, moreover in the examination of screen-size effects on cognitive access to *politically-relevant public affairs programming*. As we shall see, there is a growing body of work that signals but does not directly test the possibility that mobile technology limits cognitive access to news content. Our objective is to fill this gap in what we regard as an increasingly significant issue in the current (i.e., increasingly mobile) technological environment.

### **Mobile Constraints on Cognitive Access**

Citing a disproportionate focus on physical access to changing information technologies, Grabe and colleagues (2000) argued for research exploring the impact of changing technologies on cognitive access to information. This call was partly answered with respect to print and broadcast media (e.g. Grabe & Kamwahi, 2006) and later extended to various forms of digital media (Newhagen & Bucy, 2004). As the complexity of the media landscape has increased, however, so too have the paths and barriers to both physical and cognitive forms of access.

The very features of mobile devices that make them convenient and pervasive (i.e. portability through size and wireless capabilities) may also operate to limit cognitive access. Work suggests that mobile devices can constrain cognitive access in two ways: first, by increasing the difficulty (and costliness)

of *information-seeking and exposure*, and thereby reducing rates of exposure among the less motivated (we can think of this as a pre-exposure process still governed by cognitive capacity); and second, by making *information processing* more difficult once exposure occurs. The focus of our experiment is on the latter, but we briefly review current knowledge about each below.

## **Information-seeking and Exposure**

Smaller screens and keyboards coupled with slower and spottier connections attenuate information seeking. Past work shows that information searches on mobile devices are narrow and shallow relative to those on computers (Humphreys et al., 2013), and they focus on fewer categories (Cui & Roto, 2008), making use of fewer, and simpler, search terms (Napoli & Obar, 2014). Once results are returned, mobile users also rely more heavily on the first few results (Ghose et al., 2013). Spotty wireless coverage and network congestion also limit information-seeking because mobile users reliably abandon all slow loading content with startling speed.

Screen size also affects information-seeking by constraining the display of content in ways that shape user experiences and structure their expectations about the utility and functionality of mobile devices for information-seeking (Chae & Kim, 2004; Kim, Sundar & Park, 2011; Kim & Sundar, 2014, 2015). The memory and storage limitations on mobile devices mean that they are found lacking for complex or information-intensive activities (Hyde-Clark & Van Tonder, 2011). Cost-cutting consumers who abandoned their home broadband Internet services for wireless only access report the lack of home broadband as a major impediment to keeping up with the news (Pew 2015). Even as mobile access increases the number of exposure occurrences, it also appears to reduce the duration of each exposure occurrence (Molyneux, 2017; Pew, 2016). Rates of digital literacy also constrain mobile information-seeking: users with less digital experience report that it is more difficult to access higher volumes of information on mobile devices (Chae & Kim, 2004), and novice digital users also have difficulties with content that is not mobile-ready (Kassinen et al., 2009).

## **Information Processing**

The hypotheses tested below are derived from research on information processing. We focus on two related literatures: one on structural influences, where the effect of screen size has been an emphasis; and another on content-based influences, where the tone of information has received a good deal of attention.

### *Structural Effects on Information Processing*

Early work on the effects of screen size emerged either in response to technological change, i.e., the changing size of television sets, or as part of a general interest in how people either present or process information in text, or still and moving images (Lombard et al., 1997; Grabe et al., 1999). In recent years, work on screen size has been motivated by the growing proliferation of smartphones (Kim & Sundar, 2014, 2015). Taken together, both recent and older studies suggest that screen size matters for information processing. Screen sizes condition the psychological effects of content, both cognitively and with regard to affect (Detenber & Reeves, 1996; Lombard, 1995). Relative to small screens, large screens are better at creating a virtual reality, which is reflected in user reported rates of “enjoyment, arousal, presence, immersion, and realism” (Kim & Sundar, 2015, p. 45). Relatedly, screen and/or image size affects the extent to which people experience high levels of immersion or

transportation in response to the material presented in various forms (Grabe et al., 1999; Rigby et al., 2016; Sundar, Kang & Oprean, 2017).

Scholarly interest in the ability to “transport” audiences stems in part from the relationship between transported states and susceptibility to persuasion (Green & Brock, 2000), learning, and message reception (Burrows & Blanton, 2016). Sundar (2008) argues that screen size can affect the degree to which cognitive processing of information is conscious or controlled, thereby influencing the ease with which messages are received and processed. Specifically, larger screens facilitate a feeling of immersion, presence or “being there,” which allows for automatic and heuristic processing, requiring less cognitive effort (Hatada et al., 1980; Kim & Sundar, 2015). Research suggests that users tend to learn less information from video content on a small screen (Maniar, Bennett, Hand and Allan, 2008), and that they report higher levels of fatigue when reading on small screens (Lin et al., 2013).

Foundational work examining the effect of screen size on physiological arousal also points to the importance of screen size for audience responsiveness. Larger screens are consistently associated with greater physiological arousal relative to smaller screens (Detenber and Reeves, 1996; Lombard et al., 1997, 2000). Early work on screen size shows its effects across several domains of audience response: perceptions of reality and presence, enjoyment, arousal, attention and memory, evaluation or intensity of response (Grabe et al., 1999). Less is known about how screen size interacts with features of media content (or the context in which exposure occurs) to shape responses to content (Grabe et al., 2003) – and we consider one feature of media content, negativity, in the section that follows. Independent of content, however, the implication of past work is relatively clear: small screens structure information displays in ways that restrict cognitive access. We thus expect information displays on smaller screens to induce lower rates of attentiveness and arousal as captured by heartrate variability (HRV) and skin conductance levels (SCL). More formally, we expect:

(H1) HRV will be lower when screen size is smaller, and

(H2) SCL will decrease with screen size.

#### *Content-based Effects on Information Processing*

Information processing is also affected by the nature and tone of the content itself, i.e., its political perspective, emotional evocativeness and complexity, or negativity (e.g., Lang et al., 1995, 1996; Meffert et al., 2006). Among these possibilities, the latter is amongst the most well-investigated drivers of attentiveness and arousal.

There is a widely-documented negativity bias, a tendency for humans to prioritize negative information over positive or neutral information (Baumeister et al., 2001). This bias has been demonstrated across several fields and subfields across both physical and social sciences (Soroka, 2014.) In studies of information processing, evidence suggests that humans devote more cognitive effort to consideration of bad things, with the implication that negativity causes us to focus our attention on them for longer, and to pay more careful attention to details (e.g., Fiske, 1980). Negative news stories are typically preferred and selected over positive stories (Trussler & Soroka, 2014). And there is a growing body of evidence for negativity biases using neurological and physiological measures as well. Brain activity is more apparent among lab subjects when shown pictures depicting unpleasant images, and exposure to negative information raises heart rate, blood pressure and sweat excretion among lab subjects (Smith et al., 2003; Taylor, 1991; Soroka and McAdams, 2015).

Do these results vary alongside changes in structural constraints on information processing, such as screen size? There is good reason to believe that they do. Smaller screens should lead to decreasing attentiveness and information processing generally; and this may be reflected in more limited reactions to attention-grabbing or thought-provoking information. To be clear: (a) physiological activation increases with negativity, and (b) attentiveness and information processing is more limited on smaller screens, so (c) we expect to find more limited variation in psychophysiological activation to negative versus positive stimuli on smaller screens. Reduced variation in activation in response to the tone of news content is thus used here as a way of exploring the constraining impact that screen size has on information processing.<sup>1</sup> In short:

(H3) psychophysiological reactions to negative news content are conditional on screen size such that the effects of negativity on physiological responses will be stronger for larger screens and reduced on smaller screens.

## Methodology

The experiment used here is modelled on one originally fielded by Soroka and McAdams (2015). Our approach draws considerably from the literature on news engagement, both with respect to news content and platform (Kulta & Karjaluto, 2016; Nelson & Webster, 2017), and where screen size is concerned (e.g. Detenber and Reeves, 1996; Lombard et al., 2000), as well as the extant literature on information processing and media effects (Grabe et al., 2000). We focus on cognitive access, which we regard as a precursor to information processing, recall, memory, learning, persuasion (as in, e.g., Yoon et al., 1998; Grabe et al., 2000).<sup>2</sup>

## Design / Procedure

Participants watch a news program on their own, on a computer monitor in a quiet room, wearing noise-canceling headphones. They then complete a survey, implemented online in the same lab. Participants view seven news stories, on a range of topics, political and otherwise. Of the seven stories, one is domestic and negative, and one is domestic and positive. The remaining five are drawn from a sample of eight international stories, four positive and four negative.<sup>3</sup> All are a carefully selected (non-random) sample of real news stories from BBC World News.<sup>4</sup> They are presented in a random order, first preceded by two minutes of grey screen, and then separated by 40 seconds of grey screen.

There were a number of considerations in story selection, discussed in detail in Soroka and McAdams (2015). Suffice it to say that the general idea was to capture a range of stories that would be, in any combination, a reasonable variation of an evening newscast. There are more international stories than in the typical newscast, but this is because stories were also selected so as to be relatively timeless, so they could be fielded at any time. The stories are listed in Table 1, alongside short descriptions and

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<sup>1</sup> Testing these explanations applies insights from the literature on screens size (e.g. Lombard et al., 1996) to engage with research on mobile effects on digital citizenship (Napoli & Obar, 2014) and recent work on news negativity (e.g. Soroka & McAdams, 2015).

<sup>2</sup> This view of engagement has much in common with “attention,” at least where it is as being about more than simple exposure (e.g., Chaffee and Schlueder, 1986).

<sup>3</sup> Note that this randomization means that respondents see varying numbers of positive and negative stories – from two negative and five positive to the opposite, five negative and two positive.

<sup>4</sup> BBC News stories were used for stimuli because the original purpose of the experiment on which ours was modeled was to field a broadly cross-national study on news negativity.

two measures of tone. *Tone* is a simple binary coding, based on codes by the researchers and expert coders. *Mean Neg* is story average for *Negativity* (where -2 is most positive and +2 is most negative), based on second-by-second coding of each video, averaged across three expert coders. Full details on the coding of tone are included in Soroka and McAdams (2015). Note that their results indicate that expert coders’ assessments are in line with those from experimental participants. They are also in line with assessments from our own participants: the final column of Table 1 shows the mean score for negativity, on a scale from 1 to 7, based on a post-experiment question asking our participants to rate each story for negativity. The correlation between the mean by-second score from expert coders and the mean story-level score from participants is .95. This gives us a high degree of confidence in the negativity scores assigned to our experimental stimuli.

Table 1. Video Stimuli

Title	Description	Tone	Mean Neg	
			Experts	Participants
<i>International</i>				
Peru	Small town of Chimbote burns down	negative	1.122	4.710
May Day	May Day protests following economic downturn	negative	0.855	3.400
Niger	Food Shortages in Niger	negative	1.082	4.857
UN Sri Lanka	UN investigations in war crimes in Sri Lanka	negative	1.258	5.107
Gorillas	Gorillas are released into wild	positive	-1.031	1.645
Folding Car	New electric, folding car intended to reduce congestion	positive	-.347	1.383
Young Director	11-yr old makes stop-motion films	positive	-1.017	1.095
Cured Liver Disease	Young child recovers from liver disease	positive	-.570	1.508
<i>Domestic</i>				
Homeless	A homeless man in downtown LA is battered and shot by police	negative	1.080	5.752
Bagpipes	A US man learns how to make bagpipes	positive	-.6723	1.208

It is nevertheless the case that our measures of negativity encompass some combination of the tone of content, and other content-related factors that may be correlated with negativity, such as sounds, pacing, and so on.<sup>5</sup> All of these factors will influence both coders and participants’ ratings, after all. On the one hand, this makes for a problematic measure of negativity, insofar as it does not cleanly separate out negativity from other features. On the other hand, our measure captures the difference between negative and positive information *as it is presented in news content*, and our objective here is not to account for the impact of negative information independent of other presentational characteristics, but rather to capture average differences in reactions to negative versus positive news content.

The manipulation most critical to this study is the random assignment of participants to either large- or small-screen conditions. Note that screen size is thus a between-subjects factor, while story tone (negative and positive) is a within-subjects factor. Note also that we manipulate screen size while holding all else constant, in an effort to ensure we accurately estimate the impact of this specific

<sup>5</sup> For example, a news story about a shooting may be perceived as more negative if accompanied by the sound of a gunshot and witnesses screaming relative to the same story that does not include these audio features.

mechanism on reactions to news stories.<sup>6</sup> The randomization was implemented by flipping a coin for each participant.<sup>7</sup>

Large- and small-screen variations were identical in every way, except for the size of the window displaying the video (i.e. all participants watched the video on the same size laptop but the size of the video varied), which was either the size of a large laptop screen (roughly 13 inches wide), or the size of standard smartphone screen (roughly 4.5 inches wide). Note that this is a relatively small difference – past work focused on screen size has tended to compare very small (i.e., 12-inch) with very large (i.e., 46-inch) television screens (Lombard et al., 2000). Given that our aim here is to compare differences in attentiveness and arousal across different online mediums, however, we use this comparatively small shift in screen size (smaller even than the shift to a large desktop monitor). This should of course make statistical significance across treatments more difficult to attain.

In light of recent work illustrating that viewing angle, and not just screen size, affect responses (Bellman et al., 2009; Hou et al., 2012), we note that our laptop-based manipulation required that participants sit at roughly fixed distances from the screen. Though participants were instructed they could shift in their seats as needed for comfort, they were seated at a desk, on a chair without wheels, with their fingers connected with wires to an encoder that sat on the table in a way that set respondents' bodies about 6-8 inches from the edge of the table. (The palm of respondents' hand was placed just over the edge of the table, in front of the encoder.) Participants were unable to move the laptop or themselves around enough to significantly affect viewing angle. Physiological data were gathered using a ProComp encoder, skin conductance sensor and blood volume pulse sensor from Thought Technology.

## Participants

We rely here on data gathered from undergraduate participants in 2016, at two universities, one in the southern and the other in the Midwestern US.<sup>8</sup> There are 113 participants in total, 51 from the south and 62 from the Midwest. Participants were recruited through participant pools, and posters around campus. There are 86 female and 27 male participants. The proportion of female participants is a function of the departments from which students were drawn; even so, preliminary tests found no discernable differences across genders. The mean age of participants is 19.6 – a majority of participants are 18 and 19, with 37 respondents over 19.

## Measures

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<sup>6</sup> As our discussion indicates, several features of the mobile setting can just as feasibly govern engagement with news. We start with screen size because it has the most empirical and theoretical support from the literature relative to its competitors, and because the impact of differences in screen size are likely to remain constant over time, whereas mobile connection speeds and computing capacity will continue to improve.

<sup>7</sup> Recent work raises questions about the effectiveness and importance of balance testing (Mutz et al. 2017). Even so, randomization checks do not suggest any significant issues where balance is concerned. For instance: small-screen respondents were 77% female, while large-screen respondents were 78% female; the average age of small-screen respondents was 19.3, while it was 19.8 for large-screen respondents.

<sup>8</sup> Though we acknowledge that for many studies the use of undergraduate student samples can be a serious limitation, we suspect that our use of student samples provides a more conservative test of our hypotheses. The age cohort represented in our sample is more likely to have extensive experience with mobile devices; we expect that any differences we observe would be more pronounced among non-college participants.

Following earlier traditions in research on information processing and media effects (Bolls et al., 2001; Bucy & Bradley, 2004; Detenber et al., 1998; Simons et al., 1999), and recent work on the effects of negative news (Soroka & McAdams, 2015), and to avoid problems with inaccuracies in self-reported data on exposure to media (Boase & Ling, 2013; Prior, 2009; Taneja et al., 2016) we rely on psychophysiological indicators of activation and engagement. Skin conductance levels (SCL) are intended to capture arousal, or activation. Heart rate variability (HRV) is intended to capture some combination of activation and attentiveness. The use of variability reflects the fact that heart rate tends to decrease with heightened attentiveness, but also increase with arousal, and HRV captures the variance produced by these countervailing effects. There is of course a considerable literature in communication studies focusing on skin conductance, and our interpretation of both SCL and heart rate is in line with this past work (e.g., Bolls et al., 2001; Bucy & Bradley, 2004; Detenber et al., 1998; Lalmas et al., 2014; Marci, 2006; Peacock et al., 2011; Rúa-Araújo et al., 2016; Simons et al., 1999).

Note that there are several ways in which to measure HRV, and we rely on two: (1) the standard deviation of the NN intervals (SDNN), calculated over each news story, and (2) the Root Mean Square of the Successive Differences (RMSSD), that is, the square root of the mean squared differences of successive NN intervals.<sup>9</sup> We calculate both across all seven stories, excluding the inter-stimulus intervals.

We capture activation using skin conductance levels (SCL), measured using sensors attached to the first and third fingers on participants' non-dominant hand. We focus on the mean of 'normalized' SCL across all seven stories, where 'normalizing' SCL involves measuring all stimulus-period SCL relative to SCL during each prior inter-stimulus interval. This serves to remove variation in skin conductance across individuals, so that analysis focuses on change in SCL from before to during the video stimulus. Higher normalized SCL is taken to indicate greater levels of arousal.

In addition to the basic SCL measure, we explore a measure that captures variation in SCL across positive and negative video. Recall that we regard this more as a measure of attentiveness than arousal – SCL captures arousal, to be sure, but here we capture the extent to which arousal varies systematically with video tone. This is critical for our test of H3.

We capture the impact of tone by estimating a simple time-series model for each participant, where 'normalized' SCL for every 1-second interval is regressed on (a) the overall tone of the video (in the last column of Table 1), (b) a variable counting 1-second intervals, and (c) a variable counting the number of videos (from 1 to 7). We further interact (a) and (b), which means that our model captures the impact of negativity, controlling for time in several ways, including the tendency for the impact of tone to dissipate over the course of a news video (as found in Soroka & McAdams, 2015). We run this model for each participant, saving the coefficient for *Negativity*, which we take as an individual-level measure of the tendency to react more strongly to negative than to positive news content.

Means and standard deviations for the psychophysiological measures are as follows: SDNN has a mean of 108.777 with a standard deviation of 32.170; RMSSD has a mean of 128.809 with a standard deviation of 43.577; SCL has a mean of 0.701 with a standard deviation of 1.344; and the Negativity

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<sup>9</sup> See the Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology (1996) for a discussion of various measures of HRV.



coefficients have a mean of -0.004 with a standard deviation of 0.327.<sup>10</sup>

## Results

Results from the experiment are relatively straightforward. Regression models are presented in Table 2, with predicted values for psychophysiological measures across large- and small-screen treatments illustrated in Figure 1. The first two columns of Table 2 show OLS models regressing each measure of HRV on a dummy variable, equal to 1 for respondents under the small screen condition. The coefficient for the treatment is statistically significant and negative, as expected. The effects of screen size of both SDNN and RMSSD are also illustrated in the first and second panels of Figure 1. That results are similar for both measures is an important robustness test, confirming that our results are not dependent on one or the other measure of HRV. In line with H1, then, HRV tends to decrease with screen size, and this is evident even when the screen manipulation is relatively small – from a laptop to mobile screen size.

Table 2. OLS Regression Models of HRV and SCL, Across Small and Large Screens

	HRV		SCL	
	SDNN	RMSSD	Overall Levels	Negativity
Small Vids	-12.023* (6.260)	-20.396** (8.392)	-0.063 (0.269)	-0.116* (0.064)
Constant	114.613*** (4.362)	138.710*** (5.847)	0.739*** (0.186)	0.051 (0.045)
N	103	103	102	102
Rsqr	.035	.055	.001	.031

\* p < .10; \*\* p < .05; \*\*\* p < .01.

The third column of Table 2, and the third panel of Figure 1, shows results from regressing overall SCL on screen size. The coefficient is in the expected direction (negative), but far from statistically significant. A significant constant indicates that arousal tends to be higher during news content than in the inter-stimulus periods; but there is no sense here that screen size decreases stimulus-period arousal. We thus find no support for H2.

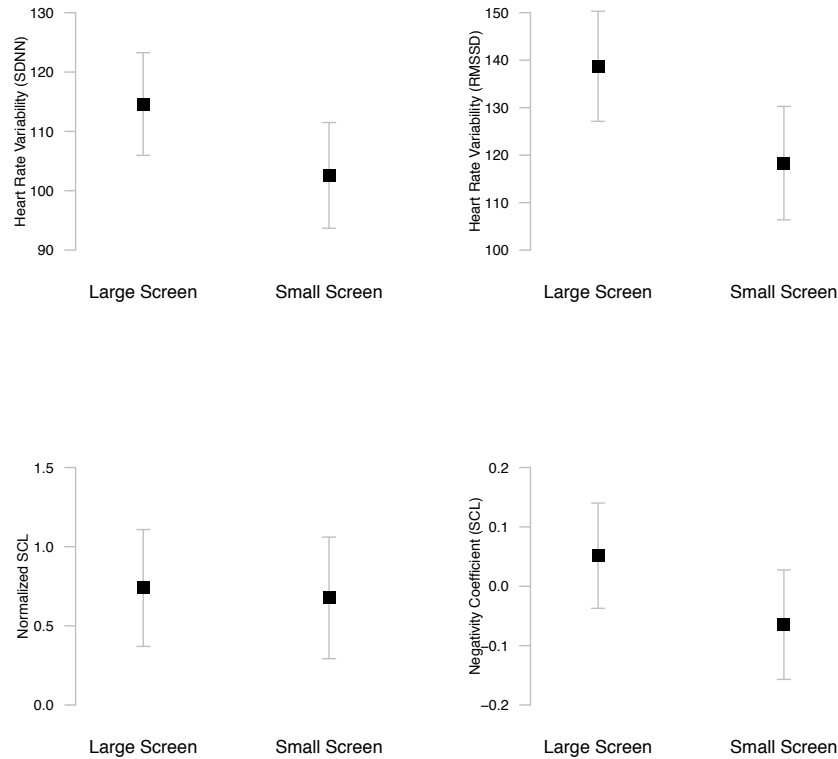
The final model in Table 2 regresses our measure of reactivity to negative versus positive content on screen size; predicted values across treatments are illustrated in the rightmost panel of Figure 1. Here, we find (weakly) significant results, in the expected direction. Note that we are using estimated regression coefficients as an independent variable here, however; and that there is a good deal of noise both in the models that produce this variable, and in the 102-respondent model in Table 2. We thus take even weak significance as an important signal in this case.<sup>11</sup> Even as overall SCL does not decrease with screen size, then, the connection between SCL and the tone of video does. We take this as a sign that, in line with H3, reactions to negative versus positive content increase with screen size. Alongside

<sup>10</sup> Note that our analyses rely only on physiological quantities, not on any self-reported data. This is because we do not expect participants to be able to accurately assess their attentiveness or information processing after the experiment. Put differently, we regard the physiological measures as the best-possible indicators of real-time attentiveness and information processing.

<sup>11</sup> For the same reason, we are not troubled by the relatively low R-squareds in the Table 2 models. Psychophysiological measures are relatively noisy, we do not expect to account for a good deal of the variance.

results for HRV, this is another indication that larger screens facilitate greater cognitive access to news content.

Figure 1. HRV and SCL, Across Small and Large Screens



## Discussion

The objective of the preceding analyses is to offer a test of the possibility that cognitive access to video news content – measured here using psychophysiological indicators of attentiveness and arousal – is reduced as viewers move to smaller screens. The literature on screen size has already demonstrated the effect of changes in screen size, of course (see citations above), but we view this as an important subject to revisit in an era in which mobile technology is viewed as one potential solution to inequalities in access to information. In contrast with past work, our test has the advantage of focusing (a) directly on video news content, and (b) on the screen sizes most relevant given current technologies. There is a growing body of literature suggesting that mobile technology may be associated with higher rates of physical access to the Internet and resulting increases in political (behavioral) engagement (e.g., Campbell & Kwak, 2010). Our results suggest that mobile technology may have both mobilizing and de-mobilizing effects.

Indeed, our results confirm that viewing video news on a small screen is associated with lower cognitive engagement with content, indicated both by decreasing HRV and a weakened connection between the tone of video and SCL. To the extent that these indicators are linked to cognitive access, a known precursor to knowledge acquisition (Grabe et al., 2000), we might expect mobile technology to be somewhat limited in its ability to bridge the digital divide. More precisely, we might expect any gains in physical access mobile technology affords to be offset by the constraints it imposes on

cognitive access.

It is worth restating that our methodological approach draws heavily on rich literatures about psychophysiological responses to news and on the effects of screen size in particular. The novelty of our contribution is as much about the application of the *physical-cognitive* access distinction to thinking about the impact of mobile technology than the findings themselves. We are not shocked that smaller screens lead to smaller activation and attentiveness. That it occurs with news content is of real significance, however; and the distinction between physical and cognitive access helps highlight the potentially countervailing effects of mobile technology, increasing one form of access even as it reduces the other.

When researchers ask whether mobile technology is expanding physical access to political information, the answer is a resounding yes. Yet mobile research on individual-level information processing and user experiences suggest real constraints on cognitive access (e.g. Kim & Sundar, 2014, 2015; Napoli & Obar, 2014). Work on the implications of mobile would benefit from the application of this useful distinction drawn from decades of important work on the effects of earlier communication technologies (e.g. Lombard & Ditton, 1997; Grabe et al., 2000). Much as it helped to reconcile conflicting accounts about the accessibility of television, it can help reconcile conflicting accounts about the effects of mobile.

Along with the contributions it offers, our study has limitations. First, although remembering news content is likely important where subsequent attitudes and/or actions are concerned, our study, based on a single relatively brief lab session, is not well-suited to capture variation in recall. To be clear: we find very high rates of recall across all conditions, regardless of screen size.<sup>12</sup> That said, past work suggests that physiological arousal is positively related to recall of video stimuli (Lang et al., 1995); that variance in physiological arousal is be connected to differences in political knowledge (Grabe & Kamhawi, 2006; Soroka et al., 2006); and that reactivity to information is associated with political participation (Gruszczynski et al., 2012). All of this work points to the potential significance of our findings for both information recall and political behavior, above and beyond the real-time reactions examined here.

Second, while we isolate the impact of screen size, we have (purposefully) ignored the fact that most mobile phones are held, not sat upright on a desk. Holding a screen brings it closer to your eyes, and involves a tactile connection that may matter for engagement and interest in news content (Bellman et al., 2009; Hou et al., 2012). We believe that testing this possibility is critical in future research. We also acknowledge that our decision to isolate screen size, while beneficial in a methodological sense, limits the external validity of our study. This is particularly true with respect to the effects of the immediate context in which devices and computers are used. In real-world settings, smartphones are often used in different situational contexts than laptops. Because previous research suggests that smartphones are often used in distracting settings that reduce attention (Campbell, 2007), we are somewhat confident that our study errs on the side of being conservative. Nevertheless, future work should more carefully interrogate the effects of context.

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<sup>12</sup> Following the experiment, participants were presented with a series of screenshots with brief story descriptions, and asked if they recalled watching that story. All participants were asked about all 10 news stories, although they only saw 7 of them. Correct recall (reporting having seen a story that the participant did actually view) ranged from 93% to 99%.

Third, we do not explore the impact of viewing-angle, due to the relatively fixed positioning of participants at desks with laptops. Holding screen distance constant was a purposeful decision; but recent work on viewing angle suggests it is an important factor (Bellman, Schweda, & Varan, 2009; Hou, Nam, Peng, & Lee, 2012) to explore in future studies as we incorporate different channels of message delivery (smartphones, computers) into our designs.

Fourth, we rely solely on psychophysiological measures as indicators of cognitive access. We maintain that on balance using psychophysiological indicators is advantageous, because they capture real-time reactions to content, and because we do not expect participants to be able to accurately assess their own attentiveness or information processing after the experiment. Psychophysiological measures also avoid potential issues with biases in self-reported media exposure (e.g. Prior, 2009). That said, even as we believe that psychophysiological measures are the best-possible indicators of real-time attentiveness and information processing, our sole reliance on these measures (i.e. the decision not to rely on self-reported data) involves trade-offs which introduce other limitations. One is the missed opportunity to triangulate using self-reports, even if those reports are ‘noisy,’ or using behavioral tasks such as secondary reaction time, which has in past work been used to examine information processing (e.g. Lang et al., 1999; Lang, 2000). That we replicate a study on the effects of news negativity, extending it by randomizing screen size, gives us a good degree of confidence in our findings. Nevertheless, future efforts may benefit from multiple measures of attentiveness and information processing, which will allow deeper exploration into mechanisms underlying the effects of screen size.

Finally, future work might benefit from focusing on how the structural presentation of information interacts with content – beyond just negativity – to shape discrete emotional responses evoked by news coverage. We rely on a simple measure of tone, but future work might consider a range of additional content characteristics that increase activation, contingent on video size. Earlier work on television news suggests that emotion-laden images produce a variety of distinct responses (Reeves et al., 1999; Newhagen, 1998). It may thus be important for future work to consider how variations in emotional content appeals moderate the effect of screen size and other structural features of content that affect attention, and even memory.

For the time being, what we have is a strong indication that screen size matters for some measures of cognitive access to news content. We take these results as an indication of the importance of further work in this area. We suspect that the results outlined above are of a smaller magnitude than might be identified when moving from a typical television-sized screen to a mobile phone-sized screen. Our ‘large’ screen is only laptop-sized, after all. The impact of moving from television to mobile phones may thus be more striking than what we have observed. Given changing news behaviors, such differences are important to further explore.

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