Appendix: The Psychological Lives of the Poor

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As touched upon briefly in the paper, many bandwidth measurements have three common features which facilitate their usage, even in challenging environments: (i) ease of administration; (ii) broad applicability; and (iii) ease of instruction. We begin by expanding on these characteristics in Appendix A. Appendix B provides details of four illustrative measurements of bandwidth: (a) Psychomotor Vigilance Task (PVT); (b) Hearts and Flowers; (c) Corsi Block-Span; and (d) Raven's Matrices. Appendix C concludes with further discussion of factors which may impact bandwidth, including physical pain, sleep deprivation, noise, and other environmental factors. Dean et al. (2017) provide a more detailed discussion of the different cognitive measurements and factors affecting bandwidth which are highlighted briefly below.

A Ideal Features of Cognitive Tasks

Before describing concrete examples of tasks to measure bandwidth in Appendix B, this section describes three ideal features of such tasks. As we discuss in the context of the four example tasks below, these features are often, although not always, features of tasks to measure bandwidth.

A.1 Ease of Administration

A highly desirable feature of cognitive tasks to measure bandwidth is ease of administration in challenging field settings with ready adaptability to many different study environments and varied populations. Different modes of data collection vary in their ease of administration. Compared to paper-and-pencil administration, electronic versions of tasks are often easier to administer, while simultaneously generating higher quality data. In particular, detailed information collected on a digital device provides fine-grained, digitally-timestamped data at every stage of the task, allowing for more sophisticated data analyses (e.g. response times). Moreover, electronic collection typically reduces the reliance on surveyor skills, thereby limiting variations due to surveyor quality and improving data quality. However, these advantages have to be weighed against challenges that can arise in studies with population groups that have no previous exposure to computers, which can impact individuals' (initial) performance on the tasks. Such challenges can be addressed by careful instruction and the implementation of practice rounds, as described below. Moreover, faster or slower versions of some of the tasks can be implemented to alter difficulty, e.g. by increasing the inter-stimulus interval (ISI), the period of time between two target stimuli in a task.

A.2 Broad Applicability

The ability to adapt measurements to a widely diverse population allows cognitive tasks to measure bandwidth in nearly any sample and context. Two features facilitate broad applicability. First,

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ideal cognitive tasks do not require formal study or substantial background knowledge. As an example, a mechanic reasoning about why an engine does not start uses both background automotive knowledge and reasoning skills. The same mechanic performing one of the cognitive tasks described below is applying his reasoning skills in a context in which he has no expertise, putting him on par with a farmer in India who has similar reasoning skills but no formal training in mechanics. Second, cognitive tasks that do not rely on knowledge of a language are also more adaptable to different contexts. One advantage of such cognitive tasks is that differences in literacy do not translate into differences in performance on these tasks. However, even cognitive tasks that satisfy these two features can never be fully independent of a person's background. Familiarity with tests, schooling, and experience with test-taking may improve performance, making comparisons of bandwidth across socioeconomic groups difficult. Fortunately, such effects do not cause bias when making comparisons within an individual over time, context, and environments, or when individuals are randomly assigned to a treatment, as these factors are, on average, consistent across experimental conditions.

A.3 Ease of Instruction

Many tests that measure bandwidth have instructions that are easily understandable by a broad population and relatively simple to administer. Ease of instruction is important because it allows for minimal surveyor supervision and rapid administration, features that make a test better-suited for wide implementation (e.g. in large-scale RCTs or nationally representative surveys). If the task is administered electronically, the software can be programmed to guide participants through the process with minimal surveyor input, intervening only at critical moments such as the beginning of the task, the end of the task, and whenever problems arise. Each of the tasks detailed below, and many others, can be explained and understood within a few minutes. However, in particular when working with study populations with low literary and numeracy, careful explanation of the tasks and practice rounds of varying difficulties are extremely valuable so as to enhance rapid learning and to avoid floor effects or unnecessary noise in the data, as discussed more detail below.

B Measures of Bandwidth

This section discusses four illustrative tasks that can be used to measure bandwidth. Each of the tasks measures a key aspect of cognitive function: (i) Psychomotor Vigilance Task (PVT) (attention); (ii) Hearts and Flowers (inhibitory control); (iii) Corsi Block-Span (memory); and (iv) Raven's Matrices (fluid intelligence). Before describing these tasks in detail, we should note that the specific categorizations of the cognitive domains targeted by different tasks are sometimes disputed within the literature. For instance, individuals' performance in memory tasks is inevitably affected by their level of attention during the completion of the task, making it difficult to fully separate the domains. Despite this caveat, there is general agreement on the primary targeted cognitive domain of the four cognitive tasks presented in this Appendix.

The tasks described below exemplify the ideal features of ease of administration, broad applicability, and ease of instructions described above. Notably, the list of cognitive tasks covered in this section is by no means exhaustive. Rather, it is meant to provide a number of illustrative examples to demonstrate the range of tests available to measure bandwidth across the spectrum of domains of cognitive function. For further reading, Diamond (2013) provides a useful overview of executive functions, along with examples of additional cognitive tasks. Links to downloads of software as well as participant and surveyor instructions for these tests (and eventually others) will be available on the authors' websites shortly.

B.1 Measuring Simple Attention: Psychomotor Vigilance Task (PVT)

The ability to maintain focus is a key cognitive function essential to a wide variety of actions and decisions in everyday life, ranging from noticing an uneven surface on the sidewalk to avoid tripping to focusing on a seminar talk. Notably, lack of focus or inattention can often have substantial negative consequences, for example, a driver's loss of focus when on a highway is a common cause of accidents.

Because attention is a multi-faceted cognitive domain, different cognitive tasks may differentially tap into the various aspects of attention. For example, vigilance, also referred to as sustained attention, is the element of ability used to detect a change during times of habituation and/or fatigue (Mackworth, 1968; Robertson et al., 1997). A widely respected cognitive task for measuring attentional vigilance is the Psychmotor Vigilance Task (PVT), discussed in detail below. Additional measures of more complex aspects of attention such as the ability to direct attention as desired and to override impulses in order to minimize interference from irrelevant stimuli, often known as inhibitory control, can be captured via tasks such as Hearts and Flowers, also discussed below (Diamond, 2013; Miyaki et al., 2000)

Attentional vigilance can be measured in multiple ways, but the Psychomotor Vigilance Task (PVT) is one of the more common methods, especially among sleep researchers (Basner and Dinges, 2011; Basner et al., 2011; Dinges et al., 1997). In a typical PVT, subjects are asked to view a blank screen and respond by tapping the screen or a key when a stimulus appears. For each trial, the key outcomes recorded for analysis are reaction time and lapses, defined as a reaction time of longer than 500 milliseconds and understood as a gap in the participant's attention. The most common outcome metric used in assessing PVT performance is the number of lapses, reported in about two-thirds of published studies (Lim and Dinges, 2008). However, other outcome metrics are of interest as well. Basner and Dinges (2011) review a number of different metrics, including mean reaction time, inverse reaction time, fastest 10% of reaction times, and median reaction time. The authors then consider which of these measures are most sensitive to individuals' sleep deprivation as induced by the experiment and conclude that the number of lapses and inverse reaction times are best-suited to measure sleep-induced reductions in alertness.

Similar to the PVT, the most common outcome measures across tasks measuring sustained attention are typically related to reaction times, which can be used to signal gaps in attention (Sarter et al., 2001). If performance in the population is consistently strong, experimenters could also consider lengthening the duration of the experiment to improve one's ability to detect differences in attention. Multiple studies have found that reaction time falls somewhat linearly as time spent on a sustained attention task increases, possibly the result of fatigue from constant vigilance (Mackworth, 1948; McCormack, 1960). Additionally, some sustained attention tasks can be made more difficult by presenting each stimulus in separate successive screens as opposed to the simultaneous presentation (Manly et al., 1999).

B.2 Measuring Inhibitory Control: Hearts and Flowers Task

Inhibitory control is a more complex type of attention which encompasses the tug-of-war between exogenous, bottom-up, automatic attention and endogenous, top-down, voluntary attention. It captures individuals' ability to control their attention, behavior, thoughts, and emotions, and it allows individuals to override internal predispositions or external lures and instead do what is (more) appropriate or needed (Diamond, 2013). The Hearts and Flowers Task, formerly known as the Dots Task, is a commonly used cognitive test used to measure inhibitory control (Davidson et al., 2006; Wright and Diamond, 2014).

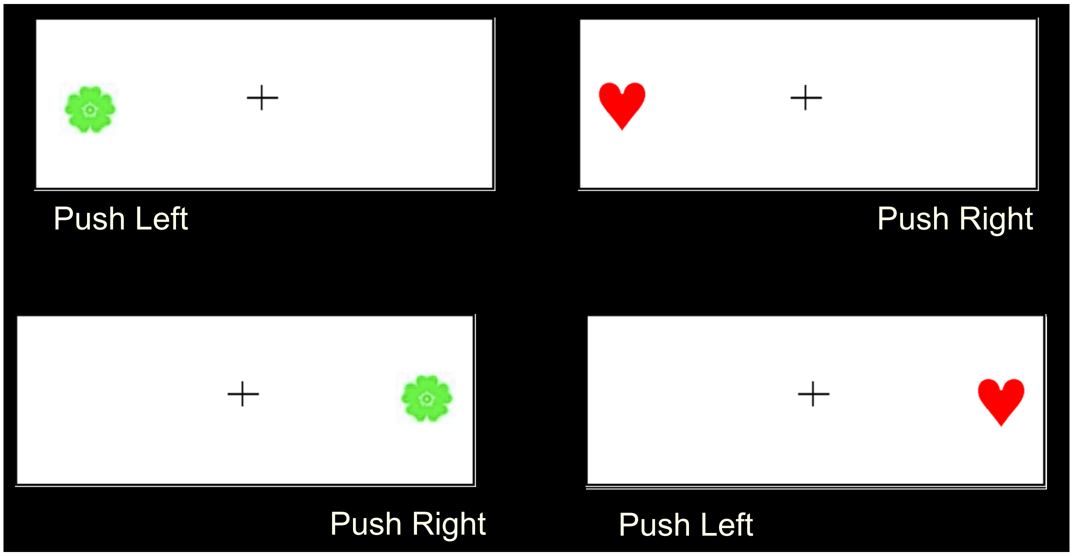

Figure 1: Hearts and Flowers

In this task, the participant views a screen on which a sequence of two types of stimuli (hearts and flowers) appear on either side of the screen. The task has two rules: (i) press the key on the same side as the stimulus if Stimulus 1 (flower) appears, and (ii) press the key on the opposite side as the stimulus if Stimulus 2 (heart) appears. Only one stimulus appears at a time, but it can appear on the left or the right side of the screen. There are commonly three trials or rounds for Hearts and Flowers in order to facilitate learning. The first trial shows only congruent stimuli (i.e., press the same side as the stimulus), the second trial shows only incongruent stimuli (i.e., press the opposite side of the stimulus), and the third trial is a mixture of congruent and incongruent stimuli. Since people have a natural tendency to immediately respond on the same side of any stimulus, responding correctly to the incongruent stimuli requires exercising inhibitory control by selectively suppressing that natural impulse (Diamond, 2013). The inhibitory control effect is usually most pronounced in the third trial with both congruent and incongruent stimuli. Researchers frequently use both accuracy and reaction time in the third trial as the measures of analysis for this task (Mani et al., 2013).

Similar to other bandwidth tasks covered in this Appendix, Hearts and Flowers functions well in a wide variety of contexts and among individuals with diverse backgrounds. Moreover, the difficulty of the task can be adjusted by altering the inter-stimulus interval, which is the time between the appearance of two stimuli, or by changing the stimulus presentation time, which is the period of time the stimulus remains on the screen. For example, Davidson et al. (2006) reduced task difficulty by extending the stimulus presentation time from 750 milliseconds for older children and adults to 2500 milliseconds for younger children (4 to 6 years old).

B.3 Measuring Memory: (Backward) Corsi Block-Span Task

The Corsi Block-Span (1972) task is another non-verbal task measuring bandwidth that is suitable for a broad population. The task targets visual-spatial short-term memory. Initially developed for clinical populations, the Corsi Task has since been used to study populations of varying ages and health conditions in many countries around the world (Berch et al., 1998).

In a typical computerized version of the task, the participant views a screen with nine scattered

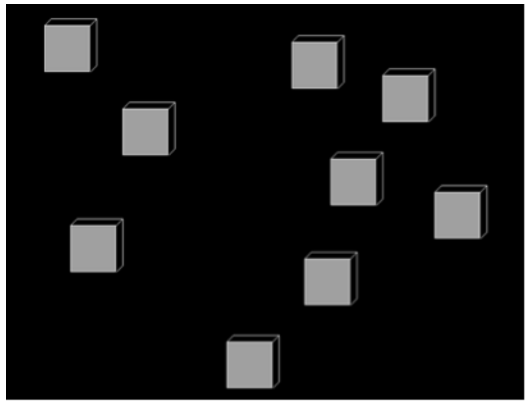

Figure 2: Corsi Block-Span

blocks as shown in Figure 2. During each trial, several blocks will light up in sequence at a fixed rate (typically one second per block). The number of blocks in the sequence is known as the span. After the sequence is shown, the participant is asked to click or tap the blocks in the same order as they originally lit up. The span usually starts at two and increases throughout the task. After every two trials, the span increases by one count if the participant answers at least one of the two trials correctly. If the participant is unable to accurately complete both trials, the task is typically discontinued. These practices can be adjusted to better fit a specific population or context though. For example, it is possible to repeat each span only once or continue to the maximum span regardless of accuracy if more appropriate.

The length of the last correctly repeated sequence, known as the Corsi Span, is recorded and frequently used as the outcome measure for analysis (Owen et al., 1990). A slightly more granular measure is the Total Score, which indicates the number of correct trials. This measurement provides more information than the Corsi Span because the participant has two trials per span length.

A different version of this task is the Backward Corsi Block-Span Task (Cornoldi and Mammarella, 2008). In contrast to the version of the task described above, the participant is asked to repeat the series of blocks in the reverse order of the presentation. This version of the task requires not only remembering, but also some manipulation of the information viewed on the screen by the participant. Accordingly this task is arguably closer to measuring working memory – the concurrent ability to store and manipulate information – than Forward Corsi Task (Baddeley, 1992; Diamond, 2013). Although the backward task would appear intuitively to be more difficult than the forward task, the empirical evidence is unclear. Most healthy participants have relatively equal forward and backward Corsi Spans (Kessels et al., 2000), although people with poor visuo-spatial memory or severe cognitive deficits typically perform slightly worse on Backward Corsi Task (Cornoldi and Mammarella, 2008).

B.4 Measuring Fluid Intelligence: Raven's Progressive Matrices

A central feature of cognitive capacity is fluid intelligence, which is the capacity to think logically and solve problems in novel situations, independent of acquired knowledge. The most prominent and universally-accepted measure of fluid intelligence, and a common component of IQ tests, is the Raven's Matrices, named after the British psychologist John Raven who developed the test almost eighty years ago (Raven, 1936, 2000). Figure 3 depicts a typical Raven's Matrix. Subjects are asked to look at the top portion of the figure, and then to identify which of options 1 through 6 in the bottom portion of the figure best completes the missing space. While the traditional Raven's Matrices sets contain around 60 such trials, a length which is reasonably easy to administer in homes, schools, and labs, recent studies have used shorter versions (e.g., 12 trials in Mani et al. (2013)).

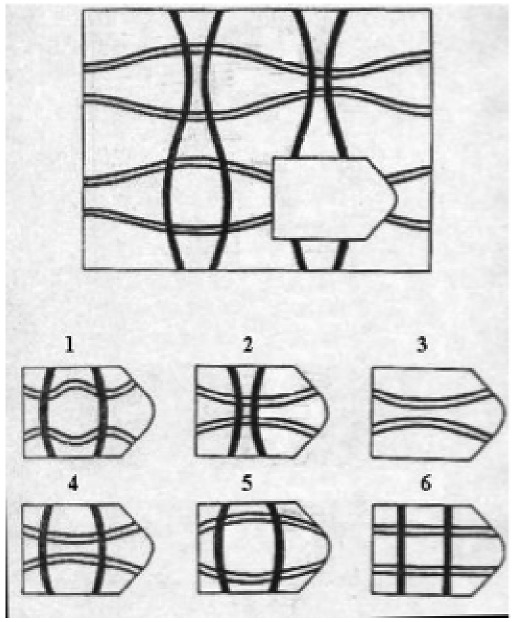

Figure 3: Raven's Matrices

There are several different ways to change the difficulty of Raven's Matrices. A simple way to make the task more difficult is to alter the number of options to choose from, for example, increasing from 6 options to 8 options in Figure 3. Another method to adjust the task's difficulty is to increase the complexity of the pattern or patterns the participants must identify and apply. Easier Raven's Matrices often involve simple matching tasks such as identifying the shape that matches a pattern, while more difficult puzzles require participants to solve multiple patterns, e.g. shape and orientation, to determine which option best fits the missing space in the figure (Prabhakaran et al., 1997). Most test booklets progress from easier to more difficult puzzles from the beginning to the end of the packet, making it easy to select puzzles of the appropriate difficulty for a given population.

B.5 Practical Concerns

A few practical concerns are important to consider before administering the tasks described above.

First, participants frequently improve their performance when completing the task repeatedly due to learning over time. As a result, heterogeneity within a study population can be large, especially during the first iteration of the task. Given the potentially large variation in initial performance, it is often beneficial to administer the task at least twice, including at least once before a treatment is administered, and then control for baseline performance to increase statistical power. Moreover, allowing participants to complete several practice rounds before starting the actual trials helps to reduce the variance unrelated to the treatment across participants.

Second, given participants' initial heterogeneity in performance and varying learning patterns, ceiling effects can occur, especially when administering the tasks repeatedly. With more practice and exposure to tasks, participants increase proficiency, potentially leading to a significant fraction of participants reaching the maximal performance. This issue is likely to arise for measures with a natural maximum such as accuracy rates. To address this concern, researchers can consider measures without a natural maximum and with greater potential variation, such as reaction times. Some researchers have also used even more granular measurements of speed and accuracy such as fastest 10% reaction times (Basner and Dinges, 2011). Moreover, many tasks can be adjusted to appropriate difficulty levels in a straightforward manner, for instance by altering the complexity of the prompted patterns, the similarity or number of the responses, and/or the allotted time people are given to respond to prevent such effects. However, piloting is often required to determine the optimal task settings to promote initial understanding while avoiding ceiling effects that can arise from repeated exposure.

C Other Factors Impacting Bandwidth

In the paper, we highlighted nutrition, alcohol consumption, and monetary concerns as examples of factors associated with poverty that have potential impacts on bandwidth. However, many other factors may also impede bandwidth, including physical pain, sleep deprivation, and environmental factors such as noise, heat, and air pollution. We provide a brief overview of the evidence regarding each of these additional factors below, keeping in mind that this list is by no means exhaustive and evidence may exist for other factors as well.

C.1 Physical Pain

Physical pain is a basic aspect of life for many of the world's poor. While evidence from developing countries is scarce, data in the developed world clearly show a (negative) pain-income gradient (Poleshuck and Green, 2008; Krueger and Stone, 2008; Stone et al., 2010; Case and Deaton, 2015). These disparities are likely to be exacerbated in the developing world where the poor are more likely to undertake heavy physical labor, experience uncomfortable living conditions, and have limited access to adequate health care and pain management tools.

While cleanly identified large-scale RCTs are scarce, a body of evidence demonstrates a link between pain and cognitive function (Moriarty et al., 2011). Pain may negatively impact various cognitive domains including attention, memory, speed of information processing, psychomotor ability, and executive function. Pain can make it difficult for individuals to focus, breaking into thought processes at inopportune moments and potentially competing for limited cognitive resources (Eccleston and Crombez, 1999). Pain may also limit one's capacity to self-regulate, a core facet of executive function, impacting one's ability to inhibit actions and behaviors (Nes et al., 2009).

Given the link between pain and impaired cognitive function, it is reasonable to hypothesize that pain may also affect aspects of daily activities such as decision-making and productivity in the labor market. Individuals with chronic physical pain may find it difficult to engage in the complex problem solving necessary to make effective business decisions such as whether to invest in capital or how best to manage inventory levels. For example, Kuhnen and Knutson (2005) found that people make more suboptimal financial decisions and are more risk adverse after the anterior insula, the part of the brain that reacts to pain, is activated. While not conclusive, this evidence suggests that chronic pain could hinder decision-making among many of the world's poor.

C.2 Sleep Deprivation

While many factors can interfere with sleep at all income levels, there are reasons to believe that the poor in particular do not sleep well, especially in urban areas and developing countries. Individuals in these environments are likely to be at high risk of sleep deprivation given the prevalence of ambient noise, heat, light, mosquitoes, stress, overcrowding, and uncomfortable physical conditions (Grandner et al., 2010; Patel et al., 2010). A robust body of evidence from randomized studies in sleep laboratories demonstrates that sleep deprivation impairs neuro-biological functioning such as reduced attention, impaired memory, and logical reasoning, which are all key features of bandwidth (Banks and Dinges, 2007; Philibert, 2005; Scott et al., 2006; Lim and Dinges, 2010; Killgore, 2010). Importantly, the impact of sleep deprivation increases with the cumulative extent of the deprivation (Van Dongen et al., 2003).

Yet, many open questions remain in this area. How and to what extent do these short-run effects of acute deprivation translate to chronic sleep deprivation in real-world environments? Does sleep deprivation affect economic outcomes outside of sleep labs, including labor market behavior (e.g. labor supply, productivity, and earnings) and decision-making (e.g. time and risk preferences, behavioral biases)? While rich evidence demonstrates that many basic cognition functions are affected by lack of sleep, limited studies have mapped the full causal chain from sleep deprivation to economic outcomes such as productivity and decision-making using bandwidth as a potential channel.

C.3 Noise, Heat, and Air Pollution

A variety of environmental factors including noise, heat, and air pollution may also tax bandwidth. These can have direct and indirect impacts on the poor, especially in the developing world and in urban areas where exposure to these environmental irritants is prominent (World Bank, 2015).

Noise. Many of the world's poor are live in urban environments replete with noise from cars honking, dogs barking, and crowds chattering. Such ambient noise may disturb individuals while they are trying to focus, work, or sleep. However, we know relatively little about the impact of such noise expose neuro-cognitive function in adults (Tzivian et al., 2015). In lab and field settings, increases in noise have been shown to impair performance on cognitive tasks, particularly those requiring broad attention and memory (Szalma and Hancock, 2011; Jones and Broadbent, 1991; Smith, 1989). Moreover, there is suggestive evidence that prolonged noise exposure is particularly likely to impact working memory and fluid intelligence, as measured by the Backward Corsi Block-Span Task and Raven's Matrices, respectively (Chiovenda et al., 2007). Additionally, children are at an increased risk of being impacted by constant noise exposure and show impairments in reading comprehension, attention, and memory (Stansfeld et al., 2005; Clark and Stansfeld, 2007). Much more evidence is needed thought to shed light on the impacts of long term exposure to noise.

Heat. Similar to other environmental factors explained above, exposure to heat may also impact cognitive ability and reduce bandwidth. Heat is especially important in developing-countries with tropical environments and frequent lack of air conditioning. When exposed to an uncomfortably high temperature, reaction time and accuracy on attention, vigilance, and inhibitory control tasks are compromised (Simmons et al., 2008; Mazloumi et al., 2014). Not only does heat exposure reduce cognitive performance, it may also impact other downstream activities. For example, excessive exposure to heat can impact productivity in manual work when the body is unable to maintain the appropriate core temperature (Kjellstrom et al., 2009). At the macro level, countries with high temperatures experience lower agricultural output and economic growth, which could be explained by workers' reduced cognitive functioning (Dell et al., 2012). However, to date, convincing evidence establishing the entire causal chain from heat to economic outcomes is limited. As global climate shifts occur, studying these causal impacts will become even more crucial, as the majority of the burden will be borne by developing countries.

Air Pollution. In addition to heat exposure, high levels of air pollution are a common disturbance for many individuals living in urban areas or near industrial sites. Since developing countries are less likely to use energy-efficient technologies and lack strong enforcement mechanisms for pollution regulations, these populations often suffer from high levels of air pollutants. Not only are pollutants harmful to physical health, there is also suggestive evidence that air pollution may be linked to bandwidth impairments on domains including attention, processing speed, working memory and verbal memory (Tzivian et al., 2015; Wang et al., 2009). While few studies have mapped the entire causal chain from pollution to economic outcomes, recent research has begun to explore the impact of pollution on downstream outcomes such as reduced worker productivity, via a bandwidth channel, in developing settings (Adhvaryu et al., 2014).

References

Adhvaryu, Achyuta, Namrata Kala, and Anant Nyshadham, "Management and Shocks to Worker Productivity: Evidence from Air Pollution Exposure in an Indian Garment Factory," *mimeo*, 2014.

Baddeley, Alan, "Working Memory," *Science*, 1992, *255* (5022), 556–559.

Banks, Siobhan and David F. Dinges, "Behavioral and Physiological Consequences of Sleep Restriction," *Journal of Clinical Sleep Medicine*, 2007, *3*, 519–528.

Basner, Mathias and David F. Dinges, "Maximizing Sensitivity of the Psychomotor Vigilance Test (PVT) to Sleep Loss," *Sleep*, 2011, *34* (5), 581–591.

_ , Daniel Mollicone, and David F. Dinges, "Validity and Sensitivity of a Brief Psychomotor Vigilance Test (PVT-B) to Total and Partial Sleep Deprivation," *Astra Astronautica*, 2011, *69* (1), 949–959.

Berch, Daniel B., Robert Krikorian, and Eileen M. Huha, "The Corsi Block-tapping Task: Methodological and Theoretical Considerations," *Brain and Cognition*, 1998, *38* (3), 317–338.

Case, Anne and Angus Deaton, "Suicide, Age, and Wellbeing: An Empirical Investigation," *NBER Working Paper 21279*, 2015.

Chiovenda, Paola, Patrizio Pasqualetti, Filippo Zappasodi, Matilde Ercolani, Daniele Milazzo, Gianfranco Tomei, Assuntina Capozzella, Francesco Tomei, Paolo M. Rossini, and Franca Tecchio, "Environmental Noise-Exposed Workers: Event-Related Potentials, Neuropsychological and Mood Assessment," *International Journal of Psychophysiology*, 2007, *65*, 228–237.

Clark, Charlotte and Stephen A. Stansfeld, "The Effect of Transportation Noise on Health and Cognitive Development: A Review of Recent Evidence," *International Journal of Comparative Psychology*, 2007, *20* (2), 145–158.

Cornoldi, Cesare and Irene C. Mammarella, "A Comparison of Backward and Forward Spatial Spans," *The Quarterly Journal of Experimental Psychology*, 2008, *61* (5), 672–682.

Corsi, Philip M., "Human Memory and the Medial Temporal Region of the Brain," *Dissertation Abstracts International*, 1972, *34 (02)*, 819B.

Davidson, Matthew C., Dima Amso, Loren Cruess Anderson, and Adele Diamond, "Development of Cognitive Control and Executive Functions from 4 to 13 Years: Evidence from Manipulations of Memory, Inhibition, and Task Switching," *Neuropsychologia*, 2006, *44*, 2037–2078.

Dean, Emma Boswell, Frank Schilbach, and Heather Schofield, "Poverty and Cognitive Function," *NBER Conference Volume on 'The Economics of Asset Accumulation and Poverty Traps.'*, 2017.

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken, "Temperature Shocks and Economic Growth: Evidence from the Last Half Century," *American Economic Journal: Macroeconomics*, 2012, *4* (3), 66–95.

Diamond, Adele, "Executive Functions," *Annual Review of Psychology*, 2013, *64*, 135–168.

Dinges, David F., Frances Pack, Katherine Williams, Kelly A. Gillen, John W. Powell, Geoffrey E. Ott, Caitlin Aptowicz, and Allan I. Pack, "Cumulative Sleepiness, Mood Disturbance, and Psychomotor Vigilance Performance Decrements During a Week of Sleep Restricted to 4-5 Hours per Night," *Sleep*, 1997, *20* (4), 267–277.

Eccleston, Chris and Geert Crombez, "Pain Demands Attention: A Cognitive-Affective Model of the Interruptive Function of Pain," *Psychological Bulletin*, 1999, *125* (3), 356–366.

Grandner, Michael A., Nirav P. Patel, Philip R. Gehrman, Dawei Xie, Daohang Sha, Terri Weaver, and Nalaka Gooneratne, "Who Gets the Best Sleep? Ethnic and Socioeconomic Factors Related to Sleep Complaints," *Sleep Medicine*, 2010, *11* (5), 470–478.

Jones, Dylan M. and Donald E. Broadbent, "Human Performance and Noise.," in Cyril Harris, ed., *Handbook of Acoustical Measurements and Noise Control*, New York: McGraw-Hill, 1991, chapter 24.

Kessels, Roy P.C., Martine J.E. van Zandvoort, Albert Postma, L. Jaap Kappelle, and Edward H.F. de Haan, "The Corsi Block-Tapping Task: Standardization and Normative Data," *Applied Neuropsychology*, 2000, *7* (4), 252–258.

Killgore, William D.S., "Effects of Sleep Deprivation on Cognition," *Progress in Brain Research*, 2010, *185*, 105–129.

Kjellstrom, Tord, Ingvar Holmer, and Bruno Lemke, "Workplace Heat Stress, Health and Productivity – An Increasing Challenge for Low and Middle-Income Countries during Climate Change," *Global Health Action*, 2009, *2* (1).

Krueger, Alan B. and Arthur A. Stone, "Assessment of Pain: A Community-based Diary Survey in the USA," *Lancet*, 2008, *371* (9623), 1519–1525.

Kuhnen, Camelia M. and Brian Knutson, "The Neural Basis of Financial Risk Taking," *Neuron*, 2005, *47* (5), 763–770.

Lim, Julian and David Dinges, "Sleep Deprivation and Vigilant Attention," *Annals of the New York Academy of Sciences*, 2008, *1129* (1), 305–322.

_ **and David F. Dinges**, "A Meta-Analysis of the Impact of Short-Term Sleep Deprivation on Cognitive Variables," *Psychological Bulletin*, 2010, *136* (3), 375–389.

Mackworth, Jane F., "Vigilance, Arousal, and Habituation," *Psychological Review*, 1968, *75* (4), 308–322.

Mackworth, N.H., "The Breakdown of Vigilance During Prolonged Visual Search," *Quarterly Journal of Experimental Psychology*, 1948, *1* (1), 6–21.

Mani, Anandi, Sendhil Mullainathan, Eldar Shafir, and Jiaying Zhao, "Poverty Impedes Cognitive Function," *Science*, 2013, *341*, 976–980.

Manly, Tom, Ian H. Robertson, Maria Galloway, and Kari Hawkins, "The Absent Mind: Further Investigations of Sustained Attention to Response," *Neuropsychologia*, 1999, *37* (6), 661–670.

Mazloumi, Adel, Farideh Golbabaei, Somayeh Mahmood Khani, Zeinab Kazemi, Mostafa Hosseini, Marzieh Abbasinia, and Somayeh Farhang Dehghan, "Evaluating Effects of Heat Stress on Cognitive Function among Workers in a Hot Industry," *Health Promotion Perspectives*, 2014, *4* (2), 240 – 246.

McCormack, P.D., "Performance in a Vigilance Task as a Function of Length of Inter-Stimulus Interval," *Canadian Journal of Psychology*, 1960, *14* (4), 265–268.

Miyaki, Akira, Naomi P. Friedman, Michael J. Emerson, Alexander H. Witzki, Amy Howerter, and Tor D. Wager, "The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis," *Cognitive Psychology*, 2000, *41* (1), 49–100.

Moriarty, Orla, Brain E. McGuire, and David P. Finn, "The Effect of Pain on Cognitive Function: A Review of Clinical and Preclinical Research," *Progress in Neurobiology*, 2011, *93* (3), 385–404.

Nes, Lise Solberg, Abbey R. Roach, and Suzanne C. Segerstrom, "Executive Functions, Self-Regulation, and Chronic Pain: A Review," *Annals of Behavioral Medicine*, 2009, *37* (2), 173–183.

Owen, Adrian M., John J. Downes, Barbara J. Sahakian, Charles E. Polkey, and Trevor W. Robbins, "Planning and Spatial Working Memory Following Frontal Lobe Lesions in Man," *Neuropsychologia*, 1990, *28* (10), 1021–1034.

Patel, Nirav P., Michael A. Grandner, Dawei Xie, Charles C. Branas, and Nalaka Gooneratne, "'Sleep Disparity' in the Population: Poor Sleep Quality is Strongly Associated with Poverty and Ethnicity," *BMC Public Health*, 2010, *10*, 1–11.

Philibert, Ingrid, "Sleep Loss and Performance in Residents and Nonphysicians: A Meta-Analytic Examination," *Sleep*, 2005, *28* (11), 1392–1402.

Poleshuck, Ellen L. and Carmen R. Green, "Socioeconomic Disadvantage and Pain," *Pain*, 2008, *136* (3), 235–238.

Prabhakaran, Vivek, Jennifer A.L. Smith, John E. Desmond, Gary H. Glover, and John D.E. Gabrieli, "Neural Substrates of Fluid Reasoning: An fMRI Study of Neocortical Activation during Performance of the Raven's Progressive Matrices Test," *Cognitive Psychology*, 1997, *33* (1), 43–63.

Raven, John, "The Raven's Progressive Matrices: Change and Stability over Culture and Time," *Cognitive Psychology*, 2000, *41* (1), 1–48.

Raven, John C., *Mental Tests Used in Genetic Studies: The Performance of Related Individuals on Tests Mainly Educative and Mainly Reproductive*, Master's Thesis, University of London, 1936.

Robertson, Ian H., Tom Manly, Jackie Andrade, Bart T. Baddeley, and Jenny Yiend, "'Oops!': Performance Correlates of Everyday Attentional Failures in Traumatic Brain Injured and Normal Subjects," *Neuropsychologia*, 1997, *35* (6), 747–758.

Sarter, Martin, Ben Givens, and John P. Bruno, "The Cognitive Neuroscience of Sustained Attention: Where Top-Down Meets Bottom-Up," *Brain Research Reviews*, 2001, *35* (2), 146–160.

Scott, Jonathon P.R., Lars R. McNaughton, and Remco C.J. Polman, "Effects of Sleep Deprivation and Exercise on Cognitive, Motor Performance, and Mood," *Physiology and Behavior*, 2006, *87* (2), 396–408.

Simmons, Shona E., Brian K. Saxby, Francis P. McGlone, and David A. Jones, "The Effect of Passive Heating and Head Cooling on Perception, Cardiovascular Function and Cognitive Performance in the Heat," *European Journal of Applied Physiology*, 2008, *104* (2), 271–280.

Smith, Andrew, "A Review of the Effects of Noise on Human Performance," *Scandinavian Journal of Psychology*, 1989, *30* (3), 185–206.

Stansfeld, Stephen A., Birgitta Berglund, Charlotte Clark, Isabel Lopez-Barrio, Peter Fischer, Evy Ohrstrom, Mary M. Haines, J Head, S Hygge, I van Kamp, and B.F. Berry, "Aircraft and Road Traffic Noise and Children's Cognition and Health: A Cross-National Study," *Lancet*, 2005, *365* (9475), 1942–1949.

Stone, Arthur A., Alan B. Krueger, Andrew Steptoe, and James K. Harter, "The Socioeconomic Gradient in Daily Colds and Influenza, Headaches, and Pain," *Journal of the American Medical Association, Internal Medicine*, 2010, *170* (6), 570–572.

Szalma, James L and Peter A Hancock, "Noise Effects on Human Performance: a Meta-Analytic Synthesis," *Psychological Bulletin*, 2011, *137* (4), 682–707.

Tzivian, Lilian, Angela Winkler, Martha Dlugaj, Tamara Schikowski, Mohammad Vossoughi, Kateryna Fuks, Gudrun Weinmayr, and Barbara Hoffmann, "Effect of Long-Term Outdoor Air Pollution and Noise on Cognitive and Psychological Functions in Adults," *International Journal of Hygiene and Environmental Health*, 2015, *218*, 1–11.

Van Dongen, Greg Maislin, Janet M. Mullington, and David F. Dinges, "The Cumulative Cost of Additional Wakefulness: Dose-Response Effects on Neurobehavioral Functions and Sleep Physiology From Chronic Sleep Restriction and Total Sleep Deprivation," *Sleep*, 2003, *26* (2), 117–126.

Wang, Shunqin, Jinliang Zhang, Xiaodong Zeng, Yimin Zeng, Shengchun Wang, and Shuyun Chen, "Association of Traffic-Related Air Pollution with Children's Neurobehavioral Functions in Quanzhou, China," *Environmental Health Perspectives*, 2009, *117* (10), 1612.

World Bank, *World Development Indicators*, Washington, DC: World Bank, 2015.

Wright, Andy and Adele Diamond, "An Effect of Inhibitory Load in Children While Keeping Working Memory Load Constant," *Frontiers in Psychology*, 2014, *5* (213), 1–9.