Bandwidth and Bad Driving

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A considerable amount of recent research demonstrates that conversing on a cellular telephone markedly diminishes a person's ability to simultaneously drive an automobile. In a recent study, Strayer, Drews and Crouch demonstrate that speaking on a ("hands free") cell-phone degrades a driver's performance about as much as having a blood-alcohol level of 0.08, see [4]. While conversing with another passenger can be somewhat distracting, it has never been suggested that it produces these sorts of severe cognitive deficits. Lacking in the literature is a convincing hypothesis to explain this marked cognitive difference. It is this gap that we hope to fill.

Since the earliest days of telephony, the bandwidth allotted for a single telephone conversation has been approximately 3000 Hertz, see [3] and the references therein. For cellular telephones, the CDMA standard voice network provides less bandwidth than a standard land-line. Indeed the bit-rate of the CDMA standard is about 1/8 that of a standard land-line. There is considerable evidence that the band used for phone conversations, 200-3200 Hertz, omits important parts of the information contained in spoken language. Indeed, many consonant sounds are impossible to distinguish on the basis of spoken language band-limited to this passband, see [2, 3]. The signal one receives through a cell phone therefore lies at or near the threshold of comprehensibility. We hypothesize that the primary cause for the large cognitive load of cell-phone conversation (versus face-to-face conversation) is the narrow bandwidth of the signal delivered by the cell-phone ear-piece. The noise often present in a cell-phone channel exacerbates an already bad situation.

Ideally, one would like to have an fMRI study demonstrating that a band-limited channel produces the cognitive demands described above. Such a study would be very difficult to perform both because of the complexity of the cognitive processes involved, and the noise produced by MR-hardware. To the best of our knowledge, this precise experiment has not yet been done. On the other hand, there are now brain activation studies, showing that, as the information content of a simple percept decreases, our perceptual "front end" makes less of an effort to "capture" the signal. While, at the same time, the processing parts of our brain make a greater and greater effort to decode these degraded signals. The later effort increases, up to a point, and then, as the information content becomes too small, it falls off. Once the input is clearly recognizable as noise, the brain is willing to ignore it, see [1]. In their seminal work, French and Steinberg

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observe that, even when individual syllables are difficult to interpret, sentence intelligibility remains high. They opine that: “The high sentence intelligibility in this case must be attributed to the listener’s ability to utilize context and guess the unintelligible sounds...” Hence, the large cognitive load of understanding bandwidth limited, noise degraded speech.

Cognitively, the cell-phone represents the worst possible combination: the signal contains too much information to be ignored, but insufficient information to be comprehended without considerable effort.

References

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