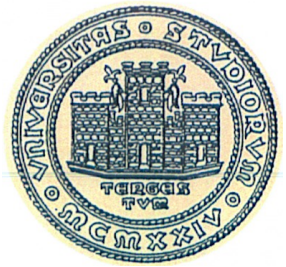


UNIVERSITÀ
DEGLI STUDI DI TRIESTE

LINGUA INGLESE
PARI A LIVELLO B2

Dipartimento di Ingegneria e Architettura

Prof. Lourdes Elizabeth Gonzalez-Valera, Ph.D.

Lesson 6

- Reading and writing processes
- Connectors / discourse markers
- Reading non-scientific articles
- Scientific papers
- Parts of a paper: a real example

Reading / Writing

Reading is a complex cognitive process of decoding symbols to derive meaning. It is a form of language processing.

Success in this process is measured as *reading comprehension*.

Reading is a means for language acquisition, communication, and sharing information and ideas.

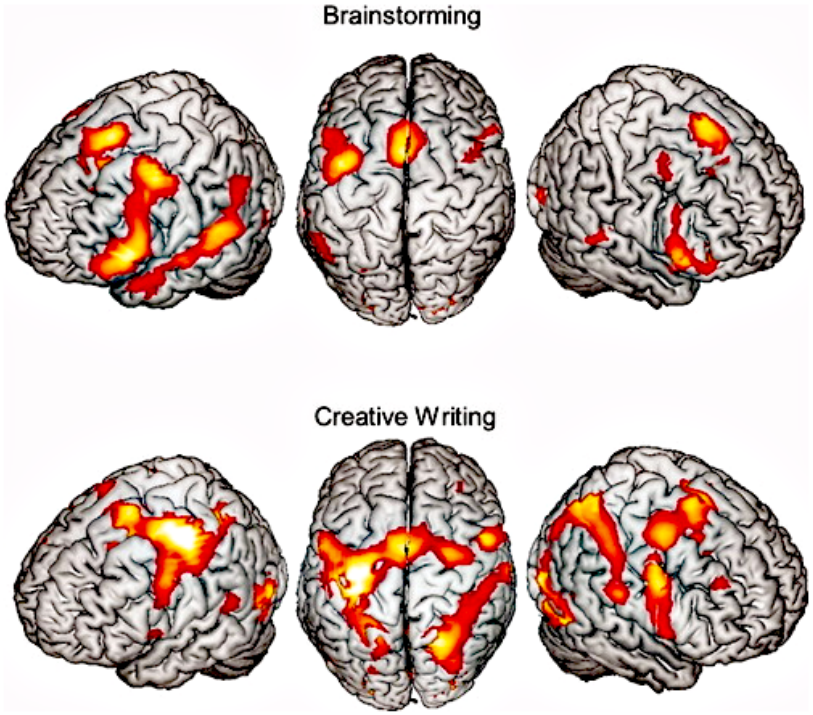
Reading / Writing

Writing is a form of human communication by means of a set of visible marks that are related, by convention, to some particular structural level of language. (britannica.com)

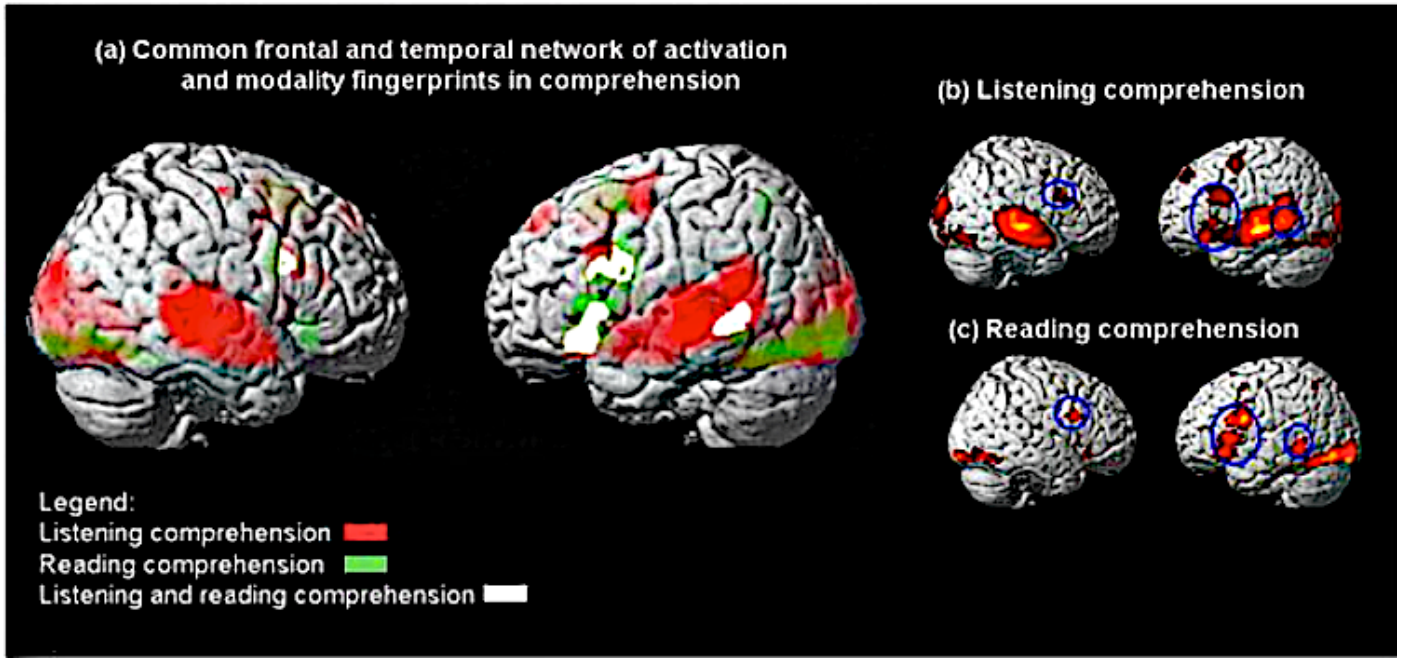
Writing is a complex cognitive process of encoding symbols to create meaning. It is a form of language propagation.

Success in this process is measured as *writing ability*

Reading



https://doi.org/10.1002/hbm.21493



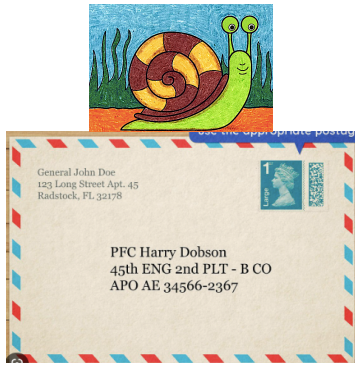
Texts we come across frequently

- Posts (blogs, WhatsApp, Telegram, Twitter Mastodon, Facebook, Cohost, Parler, Instagram, Facebook, Tik tok, etc.

- Mails
- SMS
- News
- Letters (email)

Texts we run into less often

- Letters (**snail mail**)



- Essays
- Reports
- Presentations
- Instructions
- Leaflets and flyers
- **Papers**
- **Theses**
- **Dissertations**

Connectors

or

Discourse markers:

they link sentences/ paragraphs to make discourse coherent

ADDING	SEQUENCING	ILLUSTRATING	CAUSE and EFFECT
and	first, second, third...	for example	because
also	finally	such as	so
as well as	next	for instance	therefore
moreover	meanwhile	in the case of	thus
too	after	as revealed by...	consequently
furthermore	then	illustrated by	hence
additionally	subsequently		

COMPARING	QUALIFYING	CONTRASTING	EMPHASISING
similarly	but	whereas	above all
likewise	however	instead of	in particular
as with	although	alternatively	especially
like	unless	otherwise	significantly
equally	except	unlike	indeed
in the same way..	apart from	on the other hand..	notably
	as long as	conversely	
	if		

Furthermore (adding):
People will download the app because it is fun, and furthermore, they will download the game because it is free.

Meanwhile (sequencing):
It will be a few minutes before the water boils, and meanwhile you can cut the potatoes.

Such as (illustrating):
Sarah has lots of good qualities, such as intelligence and wit.

Hence (cause and effect):
Your grammar is weak, hence the low mark I've given you.

Likewise (comparing):

• The US is sending its military into the Middle East to interfere in armed conflicts there, likewise the EU is sending arms and supplies as well.

• Sarah told Tom that she enjoyed their date, and he responded, "Likewise."

However (qualifying):

It's a good project. However, I don't think we have the money to fund it.

Whereas (contrasting):

Whereas I am a vegetarian, my whole family eats meat. / My whole family eats meat, whereas I'm a vegetarian.

Indeed (emphasising):

Two of the four new iPhones, the iPhone 14 and iPhone 14 Pro,
were indeed released last month.

Exercise:

Analysis of the article in *Brain Scan* on Satoshi Nakamoto.

The Economist.
September 1st-7th 2018

The Economist. September 1st-7th 2018

BRAIN SCAN Satoshi Nakamoto

Bitcoin's enigmatic creator may never be identified.

ON PAPER—or at least on the blockchain—Satoshi Nakamoto is one of the richest people on the planet. Bitcoin is a semi-anonymous currency and Mr Nakamoto is a pseudonymous person, so it is hard to be sure; but he is generally reckoned to own around 1.1m bitcoin, or around 5% of the total number that will ever exist. When bitcoin hit its peak of over $19,000, that made him worth around $20bn.

But Mr Nakamoto, though actively involved with his brainchild in its early history, has been silent since 2011. An army of amateur detectives has been trying to work out who he really is, but there is frustratingly little to go on. While developing bitcoin he claimed to be male, in his late 30s and living in Japan, but even that information is suspect. There are indications that he may have lived in an American time zone, but his English occasionally contains British idioms. Some of his goldbug-like comments about central banks that "debase the currency" and the evils of fractional-reserve banking led early cyber-libertarian bitcoin enthusiasts to claim him as one of their own. One thing is certain: he values his privacy. To register Bitcoin.org he used Tor, an online track-covering tool used by black-marketeers, journalists and political dissidents.

Colour legend of analysed text:

Yellow: New vocabulary

Green: the discourse markers that “glue together” the elements in a text.

Blue: Multiple adjectives + nouns phrases.

BRAIN SCAN Satoshi Nakamoto

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To register Bitcoin.org he used Tor, an online track-covering tool used by black-marketeers, journalists and political dissidents.

3 Still, the legions of sleuths have turned up various candidates, ranging from Japanese mathematicians to Irish graduate students. In 2014 Newsweek, a business magazine, fingered Dorian Prentice Satoshi Nakamoto, an American engineer. He emphatically denied the story, and the next day a forum account previously used by Mr. Nakamoto, posted, for the first time in five years, to say, "I am not Dorian Nakamoto" –though there are doubts about that account too.

4 Attention also focused on Hal Finney, an expert in cryptography, an experienced programmer and a dedicated cypherpunk. He was the recipient in the first-ever transaction conducted in bitcoin, with Mr Nakamoto as the sender. He died in 2014. Andy Greenberg, a journalist, who studied private emails between Mr Finney and Mr Nakamoto, concluded that he was probably not bitcoin's creator. And Mr Finney himself always denied that he was Mr Nakamoto.

5 Conversely, in 2016, Craig Wright, an Australian computer scientist, explicitly claimed that he was the man everyone was looking for. He invited several news organisations, including The Economist, to witness him prove his claim by using cryptographic keys that supposedly belonged to Mr Nakamoto. He did not convince his audience, so he said he would settle the matter by moving a bitcoin from Mr Nakamoto stash. He later decided against it when an online story suggested he could face arrest if he confirmed he was bitcoin's creator, on the ground of "enabling terrorism". But the story turned out to be a fake.

6 According to another theory, Mr Nakamoto is actually a group of people. But for now his, or their identity, remains a mystery. Some think his withdrawal was a matter of principle, to underline the point of a decentralised currency. Perhaps he simply wants a quiet life.

EXERCISE

1) British idioms? Examples
American idioms Examples

Is the *Bitcoin* text written in American or Britain English?
How do you recognise/recognize it.

2) Identify all the discourse markers in the text.

3) Identify the prepositional verbs.

4) Recognise multiple-adjective constructions in the text.

4) Look up the words you don’t know in the dictionary.

Other texts

- Letters
- Blogs
- Essays
- Reports
- Presentations
- Instructions
- Leaflets and flyers
- **Papers**
- **Theses**
- **Dissertations**

- **Paper** (Congress, symposium, course work)
- **Thesis** (Bachelor or Masters degree)
- **Dissertation** (Ph.D.)

Differ

- in length

- in depth

Similar:

- in style (formal)

Similar:

- in style (formal)

They **do not:**

- include informal or slang words
- include contractions, such as **isn't** and **won't**
- generally include phrases that use the words **I**, **me**, or **my**

HarperCollins. Writing (Collins Webster's Easy Learning) . HarperCollins Publishers. Kindle Edition.

-

Paper

In academic publishing, a paper is an academic work that is usually published in an academic journal. It contains original research results or reviews existing results.

Such a paper, also called an article, will only be considered valid if it undergoes a process of peer review by one or more *referees* (who are academics in the same field) who check that the content of the paper is suitable for publication in the journal. A paper may undergo a series of reviews, revisions, and re-submissions before finally being accepted or rejected for publication.

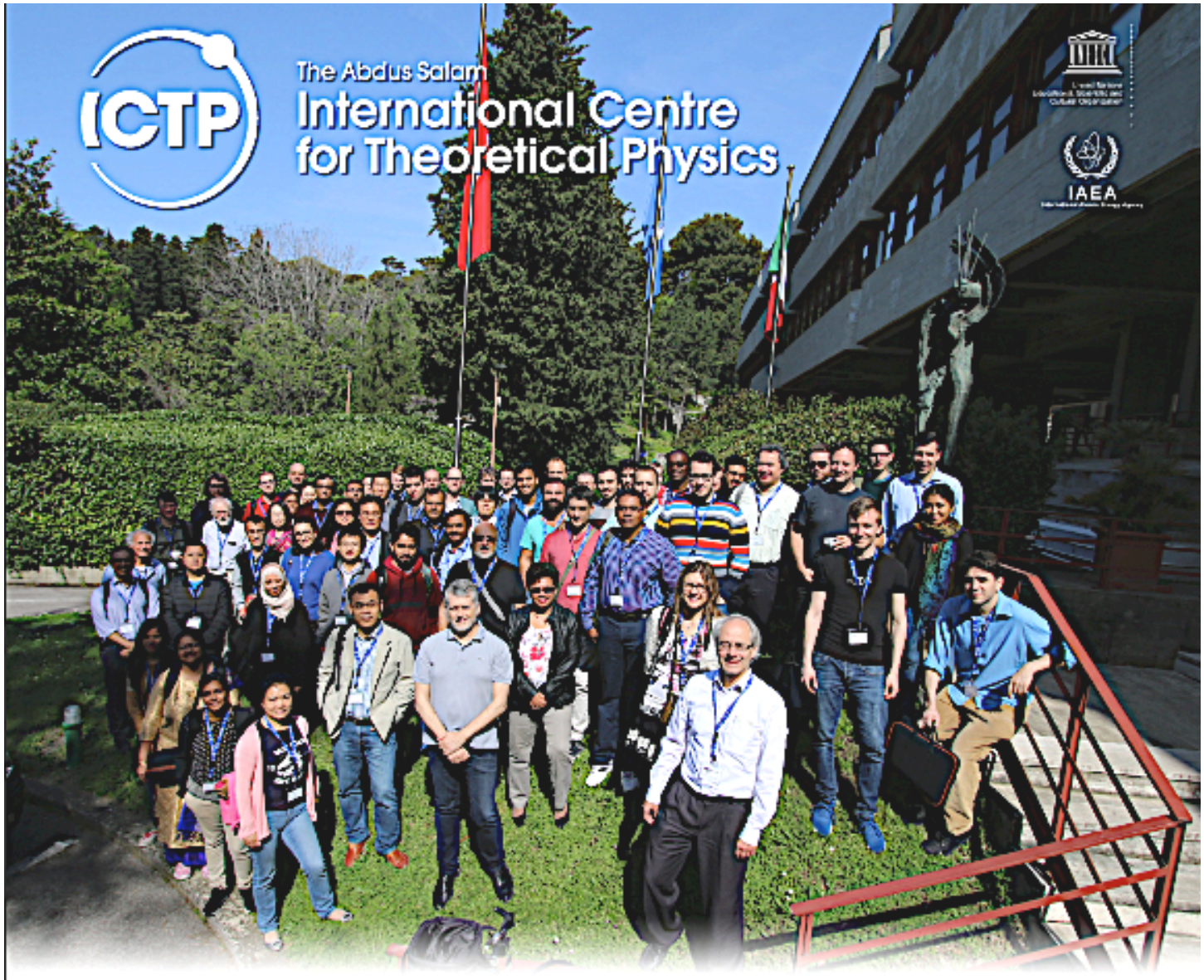
Key point to remember

Before you even start to plan your paper or academic article make sure you have a copy of the **journal' rules** on how to structure it.

HarperCollins. Writing (Collins Webster's Easy Learning). HarperCollins Publishers. Kindle Edition.

IEEE

Institute of Electrical and Electronics Engineers


ICTP
The Abdus Salam
International Centre
for Theoretical Physics
IAEA
Joint ICTP-IAEA School and Workshop on
Fundamental Methods for Atomic, Molecular and Materials Properties in Plasma Environments
16 - 20 April 2018, Miramare - Trieste, Italy

ICTP

wireless.ictp.it

Wireless Laboratory:

Provide reliable and sustainable wireless solutions to help foster science and research in Developing Countries.
Organise training activities on state-of-the-art wireless technologies.
Setup collaborations with academic partners and with international organizations.

ICTP publications: some examples

Enhancing Education in the Rural Community through Online Training

Mary-Jane Sule, Marco Zennaro, Joel G Gogwim, Clement Onime. "Enhancing Education in the Rural Community through Online Training." In: GoodTechs '20: Proceedings of the 6th EAI International Conference on Smart Objects and Technologies for Social Good, September 2020 Pages 273–277 https://doi.org/10.1145/3411170.3411262

GWO Model for Optimal Localization of IoT-Enabled Sensor Nodes in Smart Parking Systemss

Sheetal N Ghorpade, Marco Zennaro, Bharat S Chaudhari. "GWO Model for Optimal Localization of IoT-Enabled Sensor Nodes in Smart Parking Systems." In: IEEE Transactions on Intelligent Transportation Systems, doi: 10.1109/TITS.2020.2964604

FUDGE: a frugal edge node for advanced IoT solutions in contexts with limited resources

Kiyoshy Nakamura, Pietro Manzoni, Marco Zennaro, Juan-Carlos Cano, Carlos T Calafate, José M Cecilia. "FUDGE: a frugal edge node for advanced IoT solutions in contexts with limited resources." In: FRUGALTHINGS'20: Proceedings of the 1st Workshop on Experiences with the Design and Implementation of Frugal Smart Objects, September 2020 Pages 30–35 https://doi.org/10.1145/3410670.3410857

doi: Digital Object Identifier

Reading a paper
Reference:

J. Herrera-Tapia, E. Hernandez-Orallo, A. Tomas, C. Tavares Calafate, J.C. Cano, M. Zennaro and P. Manzoni. **Evaluating the use of sub-gigahertz wireless technologies to improve message delivery in opportunistic networks**, in proceedings of 14th IEEE International Conference on Networking, Sensing and Control, May 16-18, 2017, Calabria, Italy.

WHAT'S IN A RESEARCH PAPER?

A complete research paper in APA style that is reporting on experimental research will typically contain:

1. Title page
2. Abstract
3. Introduction
4. Review of Literature
5. Methods
6. Findings (results) and analysis
7. Discussion
8. Limitations
9. Future scope
10. References sections

Evaluating the use of sub-gigahertz wireless technologies to improve message delivery in opportunistic networks

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Carlos Tavares Calafate*, Juan-Carlos Cano*, Marco Zennaro†, Pietro Manzoni*
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***Abstract*—The message delivery ratio of mobile opportunistic networks strongly depends on the transmission time, which is closely related either to the mobility of users and to the communication properties of the mobile devices. A larger radio transmission range allows longer contact durations, improving the message dissemination. Furthermore, user mobility is a crucial factor to be considered, especially when the mobile nodes are vehicles, because of their limited freedom of movement and the high relative speed.**

In this paper, we evaluate the use of a sub-gigahertz wireless technology, namely LoRa (Long Range), to establish links between the mobile users in an opportunistic network in order to augment the number of contacts and their duration. We evaluate the performance of LoRa, comparing it with WiFi, using the Epidemic protocol for message diffusion with realistic vehicular traces. Through simulations, we compare the message delivery probability and the network overhead. These experiments were carried out using the ONE simulator with minor modifications to model the typical behaviour of mobile users. The results show that, in opportunistic networks, increasing the range even while reducing the available bandwidth increases the message delivery ratio.

type of networks inside the VDTN model are the Vehicular Opportunistic Networks. Opportunistic networks can also be considered as Partially Connected Networks [9], due to their ephemeral contact duration. Other authors, such the ones in [10], [11], define them as a subclass of DTNs. The reference communication model is typically based on the Epidemic protocol [9]. This protocol is widely used as a reference technique and its operations are based on the store, carry, and forward approach combined with the flooding of messages.

In this kind of disruptive wireless networks, where the communication between mobile devices is ephemeral, and the links are typically asymmetric and unstable, sending and receiving information depends on mobility and on the opportunity of contacting other devices, as long they are willing to collaborate. The duration of the contact between the nodes is a key factor in the dissemination of messages; if the contact time is too short, there will not be enough time for nodes to interchange all pending messages.

In this work we evaluate, through simulations, the performance of the Epidemic protocol in a vehicular opportunistic

What's in an abstract?

An **abstract** is a brief summary of a research article, thesis, review, conference proceeding, or any **in-depth analysis** of a particular subject and is often used to help the reader quickly ascertain the paper's purpose. When used, an abstract always appears at the beginning of a manuscript or typescript, acting as the point-of-entry for any given academic paper or patent application.

(How to write a good abstract):
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3136027/

Table 1

General qualities of a good abstract

The abstract is a condensed and concentrated version of the full text of the research manuscript. It should be sufficiently representative of the paper if read as a standalone document.
The abstract must be as detailed as possible within the word count limits specified by the journal to which the paper is intended to be submitted. This will require good precis writing skills, as well as a fine judgment about what information is necessary and what is not.
The abstract must contain as much information as possible on the analyses related to the primary and secondary outcome measures.
The abstract should not present a biased picture, such as only favorable outcomes with the study drug, or findings that support the authors' hypotheses; important nonsignificant and adverse findings should also receive mention. Thus, to the extent possible, the reader should be able to independently evaluate the authors' conclusions.

Pictorial example of abstract:

This represents your article, paper, thesis or dissertation:

A

B

C

D

Which one should be your abstract?

Pictorial example of abstract:

This is your article, paper, thesis or dissertation:

A

B

C

D

This is your abstract

Abstract

Cerebral activations involved in actual writing of a new story and the associated correlates with creative performance are still unexplored. To investigate the different aspects of the creative writing process, we used functional magnetic resonance imaging while 28 healthy participants performed a new paradigm related to creative writing: “brainstorming” (planning a story) and “creative writing” (writing a new and creative continuation of a given literary text), as well as an additional control paradigm of “reading” and “copying.” Individual verbal creativity was assessed with a verbal creativity test and creative performance with a qualitative rating of the creative products. “brainstorming” engaged cognitive, linguistic, and creative brain functions mainly represented in a parieto-frontal-temporal network, as well as writing preparation, and visual and imaginative processing. “creative writing” activated motor and visual brain areas for handwriting and additionally, cognitive and linguistic areas. Episodic memory retrieval, free-associative and spontaneous cognition, and semantic integration were observed in a right lateralized activation pattern in bilateral hippocampi, bilateral temporal poles (BA 38), and bilateral posterior cingulate cortex in a “creative writing” minus “copying” comparison. A correlation analysis of “creative writing” minus “copying” with the creativity index revealed activation in the left inferior frontal gyrus (BA 45) and the left temporal pole (BA 38). Thus, verbal creativity during “creative writing” is associated with verbal and semantic memory as well as semantic integration. Hum Brain Mapp, 2013. © 2011 Wiley Periodicals, Inc.

Abstract—The message delivery ratio of mobile opportunistic networks strongly depends on the transmission time, which is closely related either to the mobility of users and to the communication properties of the mobile devices. A larger radio transmission range allows longer contact durations, improving the message dissemination. Furthermore, user mobility is a crucial factor to be considered, especially when the mobile nodes are vehicles, because of their limited freedom of movement and the high relative speed.

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background

methods

results/ conclusion

Abstract example

Abstract

In the last decades, the demand for higher comfort levels on board of ships has increased year by year. Comfort has always been a key factor in cruise ships and pleasure yachts, though recently, the attention to the condition of seafarers has also increased. Several studies in the last years focused on how to improve comfort on board, suggesting methods and analytical instruments for the prediction of vibration and noise levels during the ship design process. Other studies investigated how to reduce the vibration transmitted from the machinery to the ship or how to reduce the vibration of radiating surfaces with the aim of reducing the noise levels on board.

Some early studies, addressed pillars as a key factor in vibration transmission, this viewpoint was shared also by shipbuilding companies. Aim of this work is to study a device for the reduction of vibration transmission through the pillars. This research is a first step in the development of such device. The main element of the isolator is a resilient element. In order to guarantee the structural capability of the device, the design loads acting on the pillars have been evaluated on a reference yacht and on a cruise ship using both scantling rules and direct FE calculation. Prototypes with different designs have been built and their dynamic characteristics have been studied in a laboratory experimental facility basing on the ISO 10846 standard for the laboratory measurement of the vibro-acoustic properties of isolators. The prototype design showing the lowest transmissibility has been tested on a real scale mock-up representing a portion of two decks with the typical structure of a cruise ship. The real scale test shows the effectiveness of the isolator in the reduction of the vibration transmitted through the pillar.

In addition, a simplified finite element model of the isolator has been set up using the data measured on the mock-up structure and the simplified model has been used to study the isolator effectiveness on a superyacht finite element model. The comparative numerical study and most of all the experimental tests led to very positive results which could pave the way to promising developments in the future.

SHARE

REVIEW | CORONAVIRUS

Prospects for a safe COVID-19 vaccine

Barton F. Haynes[1,*], Lawrence Corey[2], Prabhavathi Fernandes[3], Peter B. Gilbert[4], Peter J. Hotez[5], Srinivas R...
+ See all authors and affiliations

Science Translational Medicine 04 Nov 2020:
Vol. 12, Issue 568, eabe0948
DOI: 10.1126/scitranslmed.abe0948

Article | Figures & Data | Info & Metrics | eLetters | PDF

Abstract

Rapid development of an efficacious vaccine against the viral pathogen severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), the cause of the coronavirus disease 2019 (COVID-19) pandemic, is essential, but rigorous studies are required to determine the safety of candidate vaccines. Here, on behalf of the Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) Working Group, we evaluate research on the potential risk of immune enhancement of disease by vaccines and viral infections, including coronavirus infections, together with emerging data about COVID-19 disease. Vaccine-associated enhanced disease has been rarely encountered with existing vaccines or viral infections. Although animal models of SARS-CoV-2 infection may elucidate mechanisms of immune protection, we need observations of enhanced disease in people receiving candidate COVID-19 vaccines to understand the risk of immune enhancement of disease. Neither principles of immunity nor preclinical studies provide a basis for prioritizing among the COVID-19 vaccine candidates with respect to safety at this time. Rigorous clinical trial design and postlicensure surveillance should provide a reliable strategy to identify adverse events, including the potential for enhanced severity of COVID-19 disease, after vaccination.

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In this paper, we evaluate the use of a sub-gigahertz wireless technology, namely LoRa (Long Range), to establish links between the mobile users in an opportunistic network in order to augment the number of contacts and their duration. We evaluate the performance of LoRa, comparing it with WiFi, using the Epidemic protocol for message diffusion with realistic vehicular traces. Through simulations, we compare the message delivery probability and the network overhead. These experiments were carried out using the ONE simulator with minor modifications to model the typical behaviour of mobile users. The results show that, in opportunistic networks, increasing the range even while reducing the available bandwidth increases the message delivery ratio.

I. Introduction

Mobile Ad-Hoc Networks (MANETs) [1], [2] and Vehicular Ad-hoc Networks (VANETs) [3]–[5] are both self-forming and self-healing types of networks that provide peer-level communication links between mobile nodes without the support of fixed infrastructure. However, due to many factors but especially to user's mobility, these links may not last enough time to guarantee the message diffusion. Delay Tolerant Networks (DTNs) [6] were proposed as an alternative to disseminate and share information between mobile users. These wireless networks are being used in heterogeneous networks that lack network connectivity during longer periods than in MANETS, i.e., in the order of minutes or hours. Some authors [7] proposed their utilisation in catastrophe zones or in rural areas.

Similar to the relation between MANETs and VANETs, from the DTN model communication are derived the Vehicular Delay Tolerant Networks (VDTNs) [8] as a novel strategy to provide data transmission in vehicular scenarios. One type of networks inside the VDTN model are the Vehicular Opportunistic Networks. Opportunistic networks can also be considered as Partially Connected Networks [9], due to their ephemeral contact duration. Other authors, such the ones in [10], [11], define them as a subclass of DTNs. The reference communication model is typically based on the Epidemic protocol [9]. This protocol is widely used as a reference technique and its operations are based on the store, carry, and forward approach combined with the flooding of messages.

In this kind of disruptive wireless networks, where the communication between mobile devices is ephemeral, and the links are typically asymmetric and unstable, sending and receiving information depends on mobility and on the opportunity of contacting other devices, as long they are willing to collaborate. The duration of the contact between the nodes is a key factor in the dissemination of messages; if the contact time is too short, there will not be enough time for nodes to interchange all pending messages.

In this work we evaluate, through simulations, the performance of the Epidemic protocol in a vehicular opportunistic network when employing two different data transmission technologies: WiFi (more exactly WiFi-Direct) and the novel LoRa (Long Range) [12]. The latter provides greater communication range by working at sub-gigahertz frequencies, thus generating more contacts with greater duration, but provides a reduced bandwidth when compared to the former.

We use the ONE (Opportunistic Network Environment) simulator [13] with real GPS vehicular traces acquired from [14] while the frequency and size of messages are based on social networking applications [15]. The ONE simulator was designed and built to specifically evaluate DTN protocols and applications, and it is focused on the network layer without considering the particularities of lower layers such as physical and Media Access Control (MAC).

We evaluate the impact of both technologies in terms of ratio message delivery, latency, and buffer consumption, and the contact duration time for different buffer sizes and message TTLs (Time To Live).

The outline of the paper is as follows: an overview of related

II. Related Work

Other authors already evaluated message dissemination using vehicular opportunistic networks in urban scenarios. In [16], the authors characterise a total of three vehicular traces in China, 2 from Shanghai (bus and taxis), and one from Shenzhen. In [8], [17], [18] the authors offer a wide application of vehicular networks, where and how to employ certain communication approaches. Also they establish the differences between MANETs, VANETs and VDTNs, considering that the high mobility of vehicles leads to short contact durations limiting the amount of data transferred. They explore the routing protocols and some mechanisms to improve the collaboration and data transmission in VANETs and VDTNs.

In the same context using another trace set of 4000 taxis, the author of [19] validated the collected data, and created their own mobility model called Shanghai Urban Vehicular Network (SUVnet). In [20]–[22] the authors examine the performance of protocols in opportunistic networks considering GPS information of large cities, like Rome, Berlin, Beijing, among others. In [23], [24] the authors propose improvements to diffusion protocols using analytical models tested by simulations. In the context of VANETs, the authors of [25] extend the Internet connection between cars using embed devices such as Raspberry Pi.

In [26] is proposed POR, a new Opportunistic Routing (OR) protocol for high-speed, multi-rate wireless mesh networks that runs on commodity WiFi interface supporting TCP. Its performance is analysed with a test bed with 16 fixed nodes in a mesh distribution, showing improvements to data transfer. A similar idea [27] is used to face the problem of vehicle high speed proposing a two-way routing protocol extending the access point connectivity through opportunistic routing. Also they demonstrate how to exploit the navigation system to predict mobility and route messages.

The above listed works propose performance improvements for the Epidemic dissemination of messages, taking into account different aspects of vehicular networks. Most of these proposals have been tested through simulations and test beds, however none of them considered the use sub-gigahertz wireless technologies with longer range to improve the message diffusion.

III. Long Range Data Transmission

aspects such as: battery lifetime, capacity, communication range, interference robustness and cost. LoRa is employed in multiple application domains, such as metering, security, and machine-to-machine (M2M). LoRa can reach a range of more than 15 kilometres in a suburban environment and more than 2 km in a dense urban zone. Its bandwidth goes from 250 bps to 50 Kbps depending on geographical conditions.

LoRa significantly increases the communication range thanks to the chirp spread spectrum modulation. Chirp communication systems have been used in military activities for several years thanks to the long communication distances that can be achieved and robustness to interference thanks to the modulation which uses the entire channel bandwidth to broadcast a signal.

LoRa is one of the best alternatives in real scenarios requiring a long distance transmission of moderated bandwidth while keeping power consumption low. In this work, we are interested in long range communications in vehicular networks. Low power is a bonus but is not a strong requirement in this application because any vehicle could provide more than enough energy.

B. Message Diffusion Design

In this subsection we present a possible design for an opportunistic message transmission device for vehicular networks using LoRa. Figure 1 shows the components and their interactions to implement an opportunistic communication system. Figure 1a depicts the hardware elements: 1) a Raspberry Pi device with a WiFi dongle, 2) One connection bridge or shield, and 3) a LoRa interface connected to the Raspberry Pi via the connection bridge. These components together will allow general WiFi devices (e.g., smartphones) to communicate through the LoRa interfaces using the Raspberry Pi as a bridge. It is important to note the frequency restrictions depending on each country, e.g. in Europe LoRa is authorised to use the bands of 433MHz and 868MHz.

On the top part of figure 1b, we illustrate the interaction between devices that are embedded on the vehicles. On the bottom part of this figure we also show an example of the epidemic diffusion scheme, where a vehicle $V1$ transmits the message $M1$ to $V2$, after some time $V2$ sends the message to $V3$ when both vehicles are in communication range, and the process continues until the message arrives to its destination.

IV. Performance Evaluation

III. Long Range Data Transmission

In this section we describe some details of a possible data transmission system based on LoRa by depicting an architecture aimed to provide an opportunistic communication module for vehicular nodes.

IV. Performance Evaluation

In order to evaluate the feasibility of our proposal we employed the ONE simulator [13] using a real vehicular movement trace and generating a network load based on typical multimedia mobile messaging applications.

A. Simulation Set-up

The vehicular trace (about 21 million of records) comes from a network formed by 316 taxi cabs in the vicinity of Rome during a whole month [14]. This GPS dataset was converted to Cartesian coordinates using a traverse Mercator projection [31] centred near the Coliseum covering an area of $100km \times 100km$. Figure 2 shows how the vehicular traces are distributed around the metropolitan area. Figure 2b is a zoomed view of the previous one, showing how the main urban area is almost fully covered by the traces.

The workload considered tried to mimic the typical data-flow for a multimedia messaging application where shorter messages are far more common than larger ones. Three message sizes and frequencies were considered: (1) a short text message ($1kB$) every hour, (2) a photo ($1MB$) every 18 hours, and (3) a video or high-resolution picture ($10MB$) every 96 hours. These frequencies were based on [15], while sizes are approximations of the content produced by current mobile phone hardware.

The experiments were performed using the ONE simulator. The ONE simulator was designed and built specifically to assess protocols for message dissemination in DTN Networks, namely: Epidemic, Spray and Wait, Prophet, First Contact, Direct Delivery, and Maxprop. ONE can use real traces or synthetic mobility models like Random Walk, Random Way Point, Grid, and Linear. These mobility models can be combined to model complex behaviours with different patterns as the day progresses (like Office and Work Day). For our experiments we modified the ONE simulator. Concretely, the ONE message generator (the *MessageEventGenerator* class), that injects a new message using a random interval time. This random time is uniformly distributed from a range configured in the simulation parameters. In order to obtain a more realistic model, we implemented an independent Poisson process for

as important with LoRa because of the very low bandwidth.

V. Conclusions and Future Work

In this paper we evaluated the impact of a sub-gigahertz wireless technologies, in our case the novel Long Range (LoRa) technology, in a opportunistic network using the Epidemic protocol. The presented simulations were based on a real world movement trace from taxis of Rome and a (LoRa).

In the studied scenario, LoRa improves significantly the message delivery ratio over WiFi in the range of about 40% to 50% for TTLs of 12 and 6 hours respectively. This is because a wider communication range allows not only more contacts but also those contacts will have greater durations. As we can see, in opportunistic networks, the delivery ratio is limited by the number of contacts so the communication range becomes the most important factor after message TTL or buffer size, leaving the available bandwidth as a no-crucial factor.

The next step in our research will be to perform experiments with a real prototype implementation using embedded devices with LoRa data transmission to validate our simulation setup.

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