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PAsCAL

Projet européen H2020

PAsCAL: Enhance Drivers Behaviour and Public Acceptance of Connected and Autonomous Vehicles

L'objectif du projet PAsCAL est d'améliorer notre compréhension des effets des véhicules autonomes et connectés dans la société.

Les résultats du projet contribueront ainsi à la formation des futurs conducteurs et passagers des véhicules autonomes et connectés. Ils aideront les décideurs à évoluer vers de nouvelles formes de mobilité individuelle et collective, rendues possibles par l'introduction et l'utilisation accrue de véhicules dotés de niveaux d'autonomie élevés.



Ce projet est financé par le programme de recherche et d'innovation Horizon 2020 de l'Union européenne au titre de la convention de subvention n° 815098.

www.pascal-project.eu

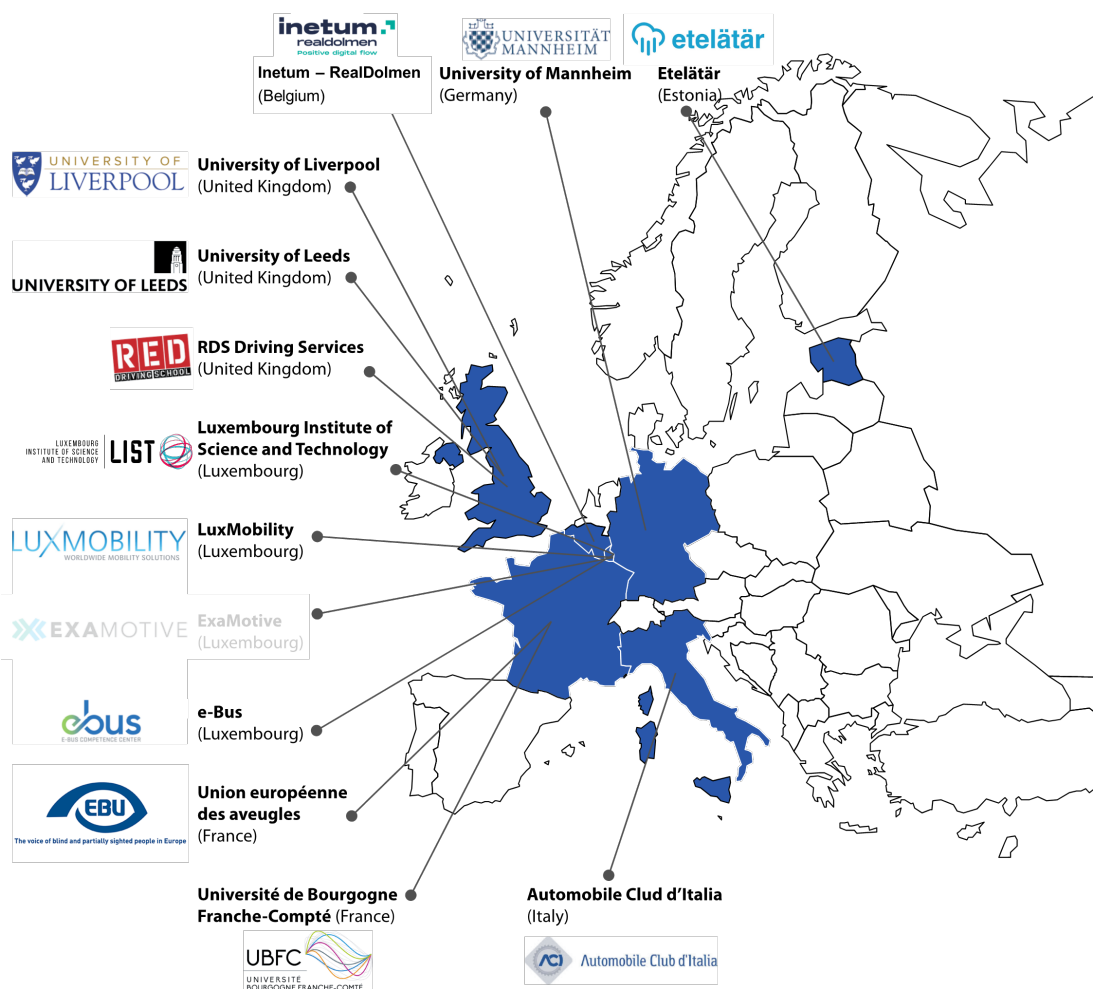
<https://cordis.europa.eu/project/id/815098/fr>

Chiffres clés

Le projet PAsCAL est doté d'un budget de 4 M€ dont 240 k€ pour le laboratoire ELLIADD.

Il mobilise 12 partenaires :

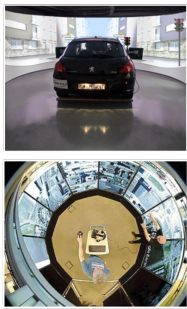
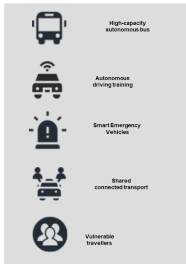
- 5 universités/centres de recherche ;
- 5 entreprises ;
- 2 associations.



Contribution ELLIADD

Le laboratoire ELLIADD, via son pôle ERCOS (Ergonomie et Conception des Systèmes), assure la coordination du workpackage 4 « Scenarios Design and Simulation Systems », qui constitue l'un des 4 piliers du projet.

Activities and outcomes

WP3 SURVEYS	WP4 SIMULATORS	WP5 TRAININGS	WP6 PILOTS
 Develop a Europe-wide multidimensional map of public acceptance	 Analyse driver's behaviour in CAV	 Investigate new "driver" training needs	 Assess attitudes towards shared modes of transport

Le WP4 comprends 5 expériences à base de simulation :

- 2 expériences conçues et opérées par ELLIADD ;
- 2 expériences conçues opérées par le LIST (Luxemburg Institute of Science and Technology) ;
- 1 expérience conçue et opérée par l'université de Liverpool.

Expérience #1 : Véhicule autonome niveau 3

L'expérience #1 s'intéresse aux interfaces homme-machine (IHM) des véhicules autonomes de niveau 3 (autonomie conditionnelle selon taxonomie SAE).



Elle a mobilisé plus de 40 sujets volontaire, âgés de 18 à 85 ans, qui ont pu expérimenter la conduite d'un véhicule autonome de niveau 3 sur le simulateur de conduite automobile Simercos.

L'expérience a permis de mesurer :

- L'efficacité et l'acceptabilité de différents signaux lors des transitions (délégation et reprise en main de la conduite) ;
- L'impact du retour d'information sur la confiance ;
- Les comportements et l'acceptabilité de conducteurs novices et expérimentés.

Expérience #2 : Navettes autonomes niveau 5

L'expérience #2 s'intéresse aux navettes autonomes de niveau 5 (autonomie complète selon taxonomie SAE) comme outils de mobilité pour les personnes à mobilité réduite (PMR).



Elle a mobilisé 12 sujets volontaires en fauteuil roulant, âges de 18 à 54 ans, qui ont pu expérimenter l'usage de 2 navettes autonomes de niveau 3 sur le plateau de réalité virtuelle immersive Prévercos.

L'expérience a permis de mesurer :

- L'acceptabilité par les PMR d'un service de transport assuré par des navettes entièrement autonomes ;
- La perception et l'accessibilité d'une navette autonome dans un contexte de trajet multimodal.

Vidéo de présentation des 2 expériences



<https://youtu.be/TSdXDtwlIG8>



**Danse
& Arts
vivants**

PLATEFORME

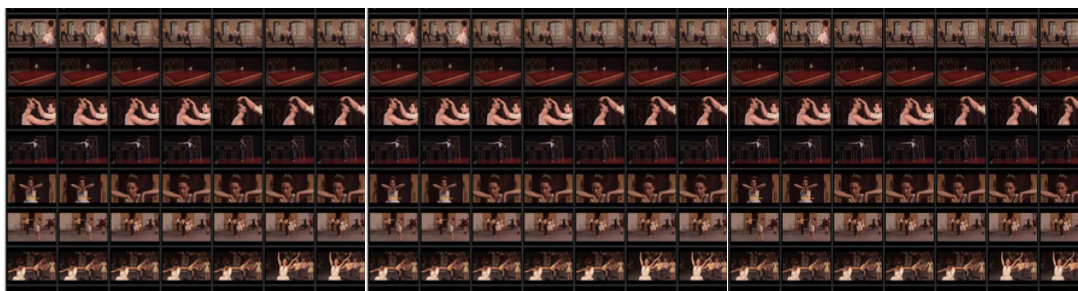
Fonds d'Archives Numériques Audiovisuelles

Présentation

La **plateforme FANA Danse & Arts vivants** fait partie des réalisations phares d'ELLIADD dans le champ des patrimoines archivistiques numérisés, avec le **Fonds d'Archives numériques Jean-Luc Lagarce**, le **Fonds Claude Louis-Combet** et le **Fonds des livrets d'opéra sous l'Ancien Régime** (voir https://fanum.univ-fcomte.fr/fanum/index.php?c_id=19). Plateforme audiovisuelle liés aux arts vivants, FANA permet de consulter des fonds d'archives audiovisuelles constitués exhaustivement autour d'un artiste, chorégraphe, metteur en scène, performeur ou d'une compagnie contemporaine.

Avec plus de **680 vidéos** ou **enregistrements sonores** soit **454 heures** accessibles sur simple demande, **1 496 fiches détaillées** et des outils pour explorer les documents, la plateforme présente actuellement en ligne **quatre fonds** liés à des chorégraphes majeurs des scènes des 20^e et 21^e siècles :

- **Fonds Dominique Bagouet - Carnets Bagouet**
- **Fonds Ingeborg Liptay - Compagnie Ici Maintenant**
- **Fonds Olivia Grandville - Cie La Spirale de Caroline**
- **Fonds Mark Tompkins - Cie I.D.A.**



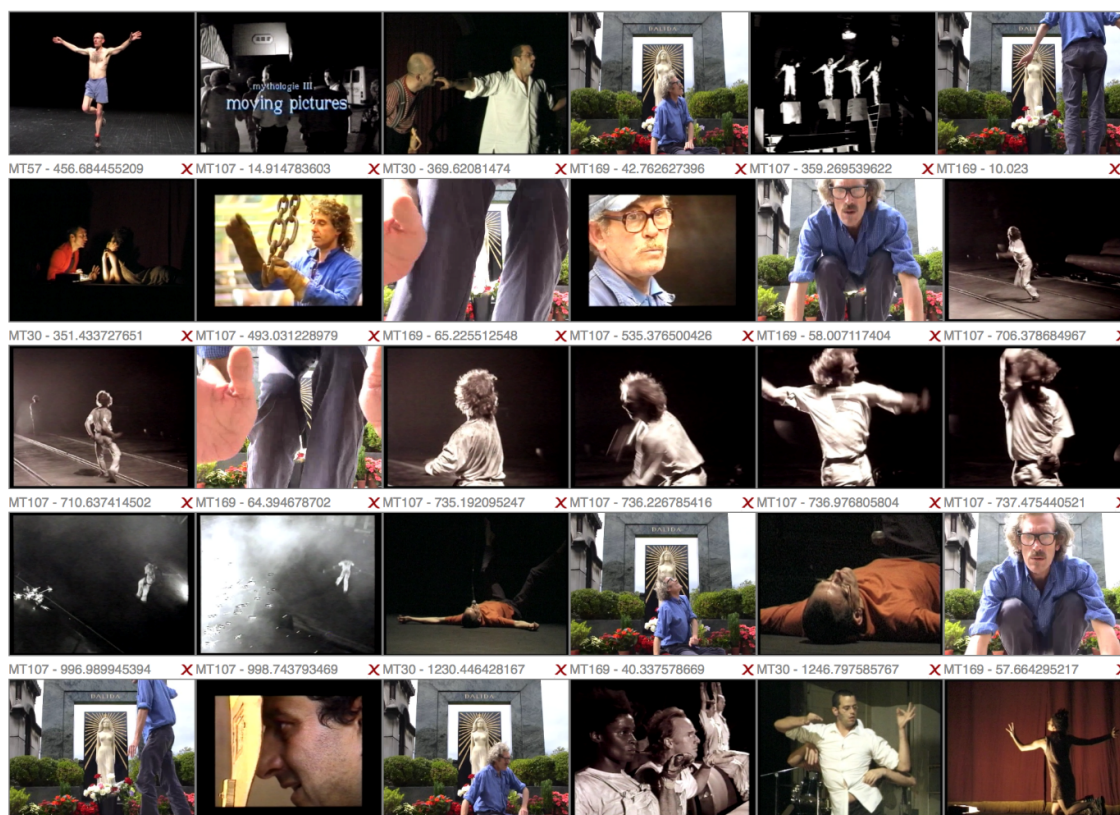


Une plateforme

4 corpus d'archives audiovisuelles

Dans un contexte où les nombreuses « traces » audiovisuelles sont rarement constituées en « archives » dans la triple dimension de conservation, de structuration et de diffusion et où les vidéos accessibles sur le web, le plus souvent en extraits, y sont bien rarement décrites, **FANA Danse & Arts vivants** offre une **plateforme de consultation en ligne** de nombreux documents audiovisuels assortis de fiches descriptives très détaillées en même temps qu'un **modèle innovant de structuration, d'indexation et d'exploration** des données.

 Images extraites

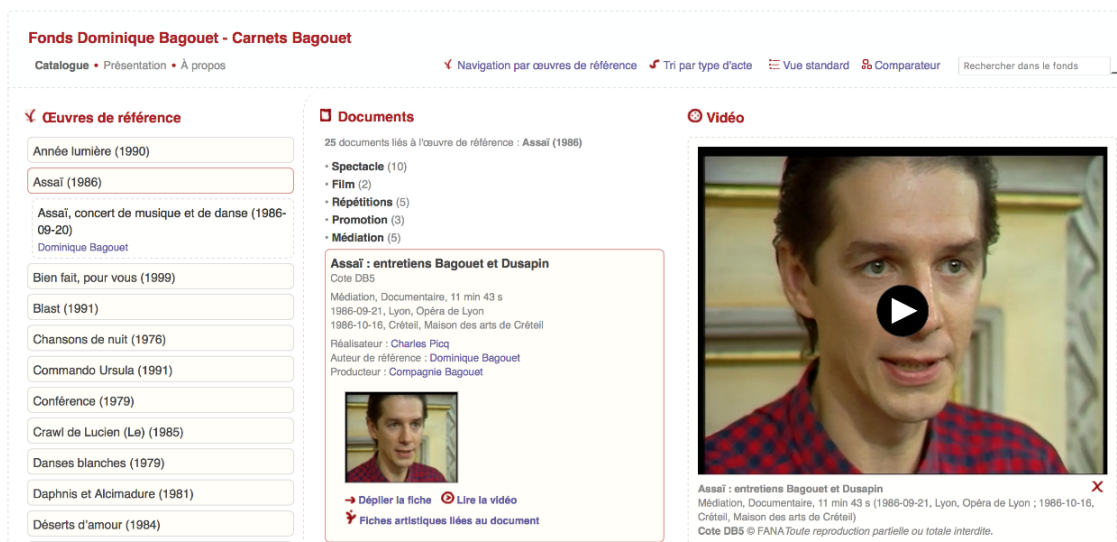


<https://fanum.univ-fcomte.fr/fana>

UNE INTERFACE CLAIRE

DES NOTICES DÉTAILLÉES

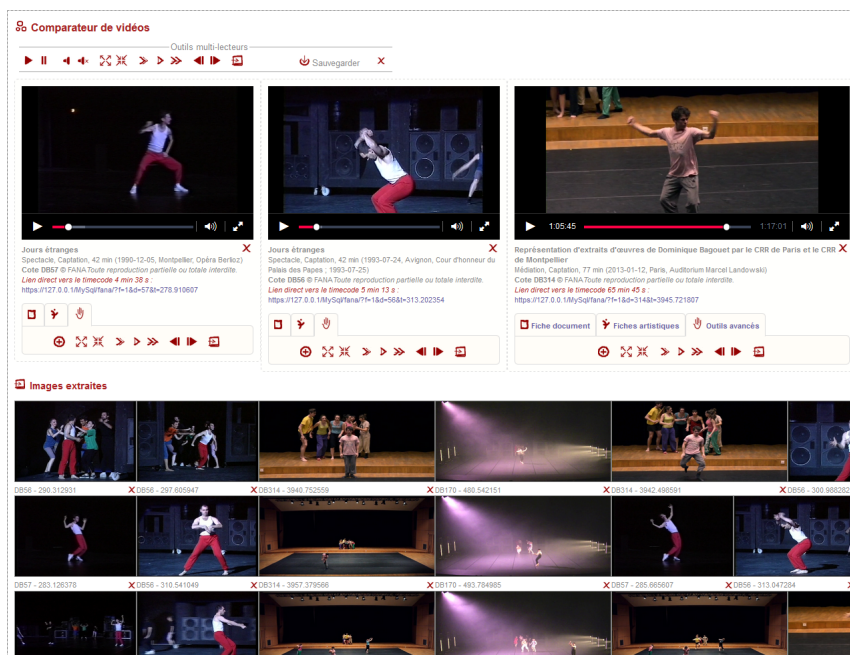
DES VIDÉOS ET DES SPECTACLES



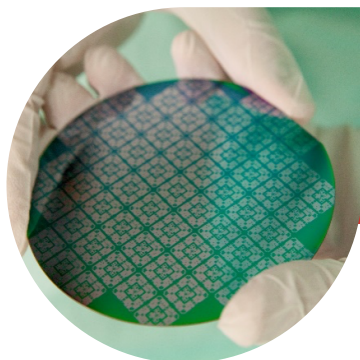
Par une interface pratique et claire, **FANA Danse & Arts vivants** s'adresse aussi bien aux acteurs de la recherche, de la création, de la formation, de la critique en arts qu'à tout amateur de spectacles vivants.

DES OUTILS D'EXPLORATION

Un comparateur de vidéos







Plateforme technologique

ESPACE ERCOS

Ensemble de solutions pour améliorer la compétitivité des entreprises à travers l'ergonomie et la conception des systèmes

La plateforme scientifique ESPACE ERCOS rassemble 5 plateaux techniques fournissant des moyens matériels et humains pour des projets de recherche, de valorisation ou de formation visant une meilleure intégration du facteur humain dans la conception et le développement de produits/systèmes/services innovants.

La valeur des produits/systèmes/services pour la personne peut notamment résulter :

- de ses potentialités techniques;
- de son utilisabilité : efficacité, efficience, satisfaction ;
- de l'estime associée : émotion, plaisir ;
- des interrelations entre ces composantes.

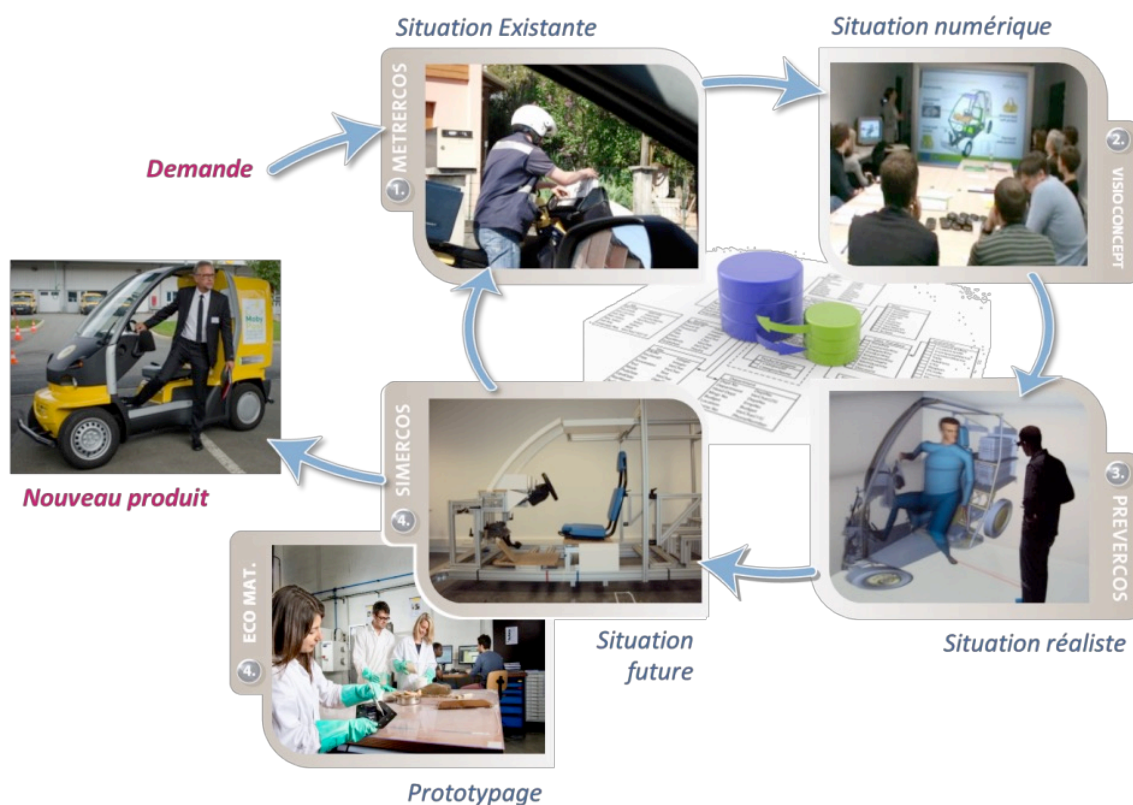
La plateforme ESPACE ERCOS est labellisée par la région Bourgogne – Franche-Comté.

URL : <http://ercos.utbm.fr/>

5 plateaux techniques

Les enseignants-chercheurs du pôle ERCOS du laboratoire ELLIADD ont développé une méthodologie originale s'appuyant sur l'utilisation des 5 plateaux techniques constituant la plateforme ESPACE ERCOS.

Ci-dessous un aperçu des 5 plateaux et de leur inscription dans cette méthodologie, illustrés par les travaux du projet H2020 MobyPost: Hydrogen for Postal Delivery.



Métrercos

Plateau de métrologie pour l'ergonomie et la conception

Équipements de métrologie mobiles destinés à l'étude et à l'évaluation des situations d'usage (pour un produit) ou de travail pour une situation de travail :

- Mesure des ambiances physiques environnementales (ambiances lumineuse, sonore, climatique et vibratoire) ;
- Mesures physiologiques et électrophysiologiques (fréquence cardiaque, températures interne et cutanée, électromyographie...) ;
- Mesures d'efforts (dynamométrie, nappes de pression) ;
- Capture de mouvements pour analyse cinématique (goniomètres, centrales inertielle, capture optique...) ;
- Eye tracking pour l'étude des stratégies visuelles ;
- Captation vidéo pour l'analyse de l'activité d'usage/de travail.



URL : <http://ercos.utbm.fr/plateformes/metrercos/>

Visio Concept

Plateau de travail collaboratif autour de la maquette numérique

Dispositif de visualisation 3D sur écran géant.

En rassemblant les différents métiers du groupe projet autour d'une visualisation partagée de la maquette numérique représentant les premières solutions/les premiers concepts, il permet de susciter une dynamique d'échanges fructueux sur des aspects techniques, économiques, sociaux, design et ergonomiques.



URL : <http://ercos.utbm.fr/plateformes/visio-concept/>

Prévercos

Plateau de réalité virtuelle immersive pour l'ergonomie et la conception

Le plateau Prévercos dispose de deux dispositifs de réalité virtuelle complémentaires, permettant de visualiser, d'évaluer et d'optimiser les produits/systèmes/services modélisés :

Un CAVE 3 écrans : multi-utilisateurs, il est particulièrement approprié pour des revues de projets multi-métiers. Il aide les acteurs de la conception à converger puis à valider un concept/une solution acceptable sur les plans technique, économique, social, design et ergonomique.

Des casques de réalité virtuelle sans fil, procurant une immersion à 360°. Déplaçables sur le terrain/en entreprise, ils peuvent aisément être augmentés à l'aide de supports tangibles fournis par le plateau Simercos.



URL : <http://ercos.utbm.fr/plateformes/prevercos/>

Simercos

Plateau de simulation pour l'ergonomie et la conception

Dispositifs de simulation partiellement ou totalement physique destinés aux tests et validations nécessitant des supports tangibles.

Le plateau Simercos comprend notamment un simulateur de conduite automobile et un simulateur d'architecture habitacle (SArHa).

Ce plateau est dédié à l'observation, l'analyse et l'expérimentation de situations d'usage, permettant de tester et de valider les prototypes co-construits avec l'ensemble des acteurs du projet, réunissant ingénieurs, designer, ergonomes, utilisateurs... pour aboutir à un produit/système viable, fiable, ergonomique, fabricable, recyclable...



URL : <http://ercos.utbm.fr/plateformes/simercos/>

Eco-matériaux

Prototypage et caractérisation des matériaux bio-sourcés

Le plateau éco-matériaux se destine au développement de connaissances sur les matériaux bio-sourcés, pour une conception de produits durables et centrée sur la personne.

Il vise particulièrement à répondre aux applications nécessitant allègement et réduction des vibrations, à l'image des outils à main et des machines portatives. Il comprend :

- des équipements de maîtrise de la chaîne de transformation et de mise en forme de matériaux biosourcés ;
- du matériel de caractérisation mécanique et thermo-physique (DSC, DTC...).



URL : <http://ercos.utbm.fr/plateformes/matercos/>





CONFÉRENCE

H2PTM'19

Conférence Internationale – H2PTM'19

« De l'hypertexte aux humanités numériques »

Fidèle à l'esprit pionnier de ses débuts, la Conférence Internationale **Hypertextes et Hypermédias. Produits, Outils et Méthodes (H2PTM)** est un rendez-vous scientifique incontournable qui rassemble des chercheurs en sciences de l'information et de la communication, en informatique, en sciences cognitives, ainsi que des artistes créateurs d'œuvres numériques. Traditionnellement ancrée à Paris (Université Paris 8, Laboratoire Paragraphe), organisée tous les 2 ans depuis 1989, la conférence internationale H2PTM a célébré ses 30 ans en 2019. La 15e édition de H2PTM a été organisée par le laboratoire ELLIADD à Montbéliard, du 16 au 18 octobre 2019.

Objectifs de la conférence

Trente ans après la naissance du Web et la 1ère édition de la Conférence H2PTM, cette 15e édition est l'occasion pour les chercheurs de confronter leurs argumentaires concernant la navigation et la recherche d'informations, le patrimoine et la médiation culturelle, ainsi que d'autres thèmes qui animent la communauté internationale, comme les Humanités Numériques. Grâce à leur réflexion critique sur la genèse du numérique, les sciences de l'information et de la communication montrent que, malgré l'impact du numérique sur le processus de production et d'interprétation des données, les questions posées avec insistance par les sciences humaines et sociales demeurent centrales pour saisir la complexité des processus de recherche d'information et de communication, et confirment la nécessité dépasser une approche strictement quantitative.



Figure 1 – Cérémonie d’ouverture (de gauche à droite) : Olivier JOUFFROY (Directeur de l’UFR STGI), Macha WORONOFF (Vice-présidente du Conseil d’administration de l’Université de Franche-Comté), Charles DEMOUGE (Président de Pays de Montbéliard Agglomération), Ioan ROXIN (Directeur du laboratoire ELLIADD), Imad SALEH (Directeur du laboratoire Paragraphe), Nasreddine BOUHAI (membre du laboratoire Paragraphe)

Bilan de la conférence

Cette édition jubilaire (la 15e) a rassemblé plus de cent participants, a proposé 24 communications orales (sélectionnées sur 54 reçues), organisées dans neuf sessions de travail (e.g. Médiation des savoirs et apprentissage ; Hypertexte, navigation et web sémantique ; Médias sociaux, culture & pratiques numériques; Visualisation et traitement de l’information; Hypertexte, navigation et recherche d’informations). Les actes de cette conférence sont rassemblés dans un volume publié par ISTE Éditions <https://www.istegroup.com/fr/produit/h2ptm19/>.

Chacun de trois jours a démarré par une conférence magistrale :

- « Les humanités numériques : de l’épistémologie à la culture », de Bruno BACHIMONT (Directeur de la Recherche et de la Valorisation de la Faculté des Sciences de Sorbonne Université) ;
- « Des traces numériques à la visualisation des attentions collectives », de Boris BEAUDE (Directeur du Laboratoire LaDHUL, membre du STSLab, Université de Lausanne) ;
- « L’Intelligence et la stupidité artificielles. Le jeu de l’imitation », de Ioan ROXIN (Directeur du laboratoire ELLIADD, Université de Franche-Comté).

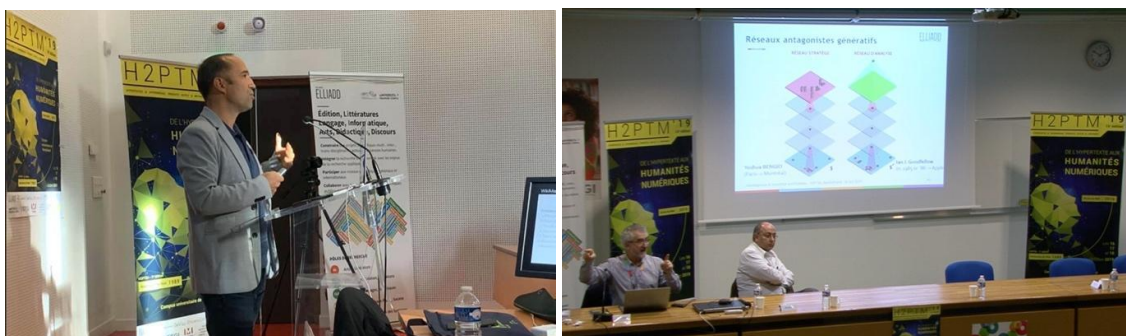


Figure 2. Conférence plénière du Pr. Boris BEAUDE (à gauche) et Pr. Ioan ROXIN



Figure 3. Échanges entre les chercheurs autour de leurs travaux de recherche.

Cette édition de la conférence internationale H2PTM a offert aussi des échanges très riches, sur le plan scientifique et humain. La conférence H2PTM'19 a rassemblé une centaine de chercheurs et d'artistes, comptant des représentants de 6 universités étrangères et 21 universités françaises, qui se sont retrouvés durant trois jours à Montbéliard. Les participants ont pu partager et discuter de leurs travaux sur les hypertextes et hypermédias à l'ère des Humanités numériques.

Dans un esprit d'ouverture sur la création et les hypermédias, quatre œuvres numériques ont été dévoilées au public au sein du showroom du pôle Numérique de Bourgogne Franche-Comté.



15^{édition} H2PTM'19

Œuvres numériques

Pendant toute la durée de la conférence, du mercredi au vendredi inclus, des œuvres numériques sont installées dans le hall d'accueil du bâtiment Numerica (voir la carte du campus page suivante).

MY LITTLE IDENTITY

Françoise CHAMBEFORT (Doctorante, ELLIADD)

MACHIN LEARNING

Étienne CANDEL (PR, ELICO / Lyon 3) et Julien JASSAUD (Artiste programmeur)

PLAY MUSIC FOR MY POEM

Philippe BOOTZ (MCF HDR, Paragraphe) et Nicolas BAUFFE (MIM)

CONFESSIONNAL

Sébastien AUGIER (Doctorant, PRAG, ELLIADD / IUTBM / MMI)

Figure 4. Présentation des œuvres numériques dans le programme de la conférence

Personnalités étrangères invitées

Prof. Boris BEAUDE, Directeur du Laboratoire LaDHUL, membre du STSLab, Université de Lausanne

Prof. Samia BEN RAJEB, laboratoire BATir (Building, Architecture and Town Planning), Université Libre de Bruxelles

Prof. Renée BOURASSA, Université Laval, chercheure affiliée au Laboratoire NT2, au Centre de recherches intermédiaires sur les arts, les lettres et les techniques (CRIalt) et au Laboratoire de muséologie et d'ingénierie de la culture (LAMIC)

Prof. Jean-Marc LARRUE, Département des littératures de langue française / Université de Montréal, Canada

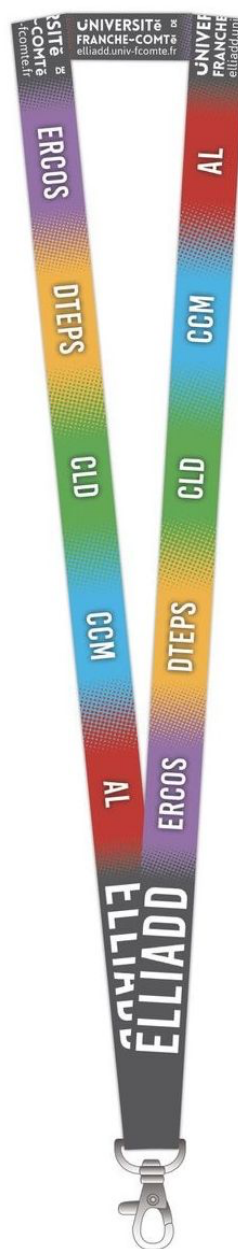
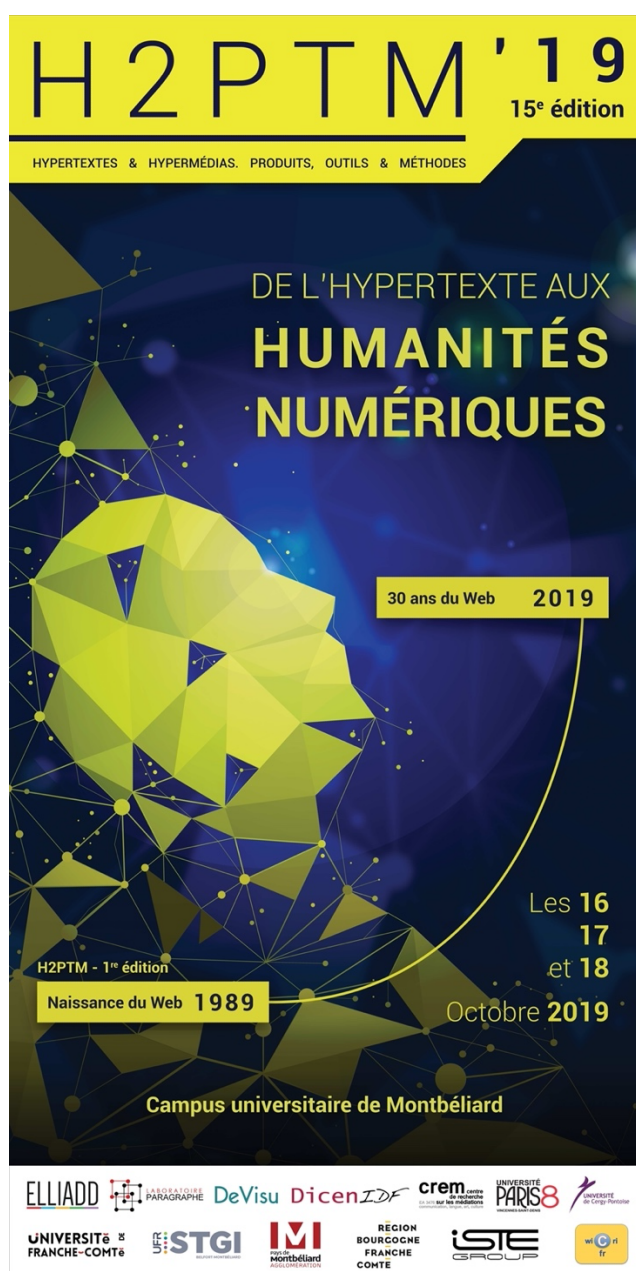
Prof. Pierre LECLERCQ, Faculté des Sciences Appliquées de l'Université de Liège, LUCID-ULg, Lab for User Cognition & Innovative Design, Belgique

Programme culturel

Outre sa dimension scientifique, la conférence H2PTM'19 a été l'occasion pour les participants de découvrir le patrimoine culturel de Montbéliard, lors d'une visite du Château des Ducs de Wurtemberg et du Temple Saint-Martin (le plus ancien édifice du culte protestant en France). Le repas de gala a été organisé au Musée de l'Aventure Peugeot Citroën que les participants ont eu la chance de pouvoir visiter avant le début des festivités.



« Livre d'Or H2PTM – Montbéliard 2019 », <https://sites.google.com/view/h2ptm19-livre-or/accueil>



*De l'hypertexte aux humanités
numériques*

H2PTM'19

coordonnateurs

Ioan Roxin, Imad Saleh, Nasreddine Bouhaï

Sylvie Leleu-Merviel, Yves Jeanneret

Manuel Zacklad, Luc Massou



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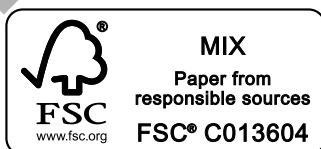
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De l'hypertexte aux humanités numériques

Actes de H2PTM'19

16, 17 et 18 octobre 2019 au campus universitaire
de Montbéliard

coordonnateurs

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Imad Saleh
Nasreddine Bouhaï
Sylvie Leleu-Merviel
Yves Jeanneret
Manuel Zacklad
Luc Massou

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COMTÉ



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Interreg

France-Wallonie-Vlaanderen



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GoToS3

C2L3Play

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 YVES JEANNERET, CELSA-Paris Sorbonne (France)
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LABORATOIRE ELLIADD, Université de Franche-Comté (France)

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Revue SEMEN

Revue et séries portées par ELLIADD

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- « Annales littéraires »
- Semen, revue de sémiolinguistique des textes et discours

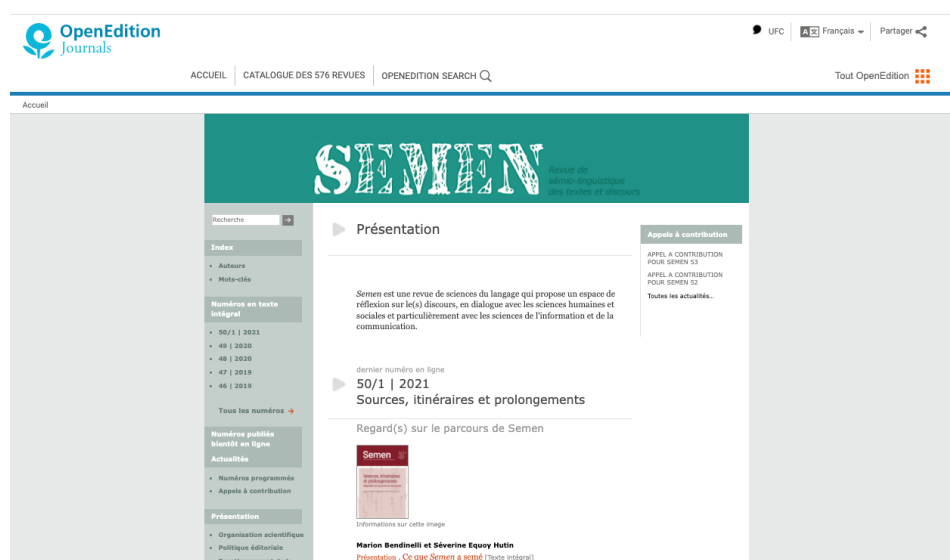
Assiette scientifique de la revue SEMEN

Fondée par Thomas Aron et Jean Peytard, *Semen* est une **revue semestrielle de Sciences du langage, internationalement reconnue et qualifiante par le CNU en 7^{ème} et 71^{ème} section**. Elle vient de publier en 2021 son 50^{ème} numéro.

L'assiette scientifique de la revue est restée en adéquation avec les grandes évolutions de la recherche autour différentes ouvertures :

- à l'**épistémologie et l'histoire des Sciences du langage** avec par exemple les numéros 33 (*Les notes manuscrites de Benveniste sur la langue de Baudelaire*, coordonné par J-M Adam, et C. Laplantine) et 34 (*Texte, discours, interactions. Nouvelles épistémologies*, coordonné par Marie-Anne Paveau) ;
- à la **pragmatique** avec le numéro 38 (*Pragmatique de la répétition* coordonné par V. Magri-Mourgues et A. Rabatel) ;
- à l'**anthropologie** avec le numéro 37 (*Approches discursives des récits de soi* coordonné par S. Nossik) ;

- aux **théories de l'argumentation** avec le numéro 35 (*Modes de sémiotisation et fonctions argumentatives des émotions*, coordonné par I. Hekmat, R. Micheli, A. Rabatel),
- aux **interactionnistes** avec le numéro 40 (*Politesse et violence verbale détournée* coordonné par C. Moïse et A. Oprea) ;
- au **dialogue avec les SIC** avec par exemple les numéros 36 *Les nouveaux discours publicitaires* coordonné par M. Bonhomme, 39 *Discours et contre-discours dans l'espace public* coordonné par J. Auboussier), 41 *L'énonciation éditoriale* coordonné par M. Arabyan, 42 *Le discours hypertextualisé* coordonné par J. Simon, 45 *Deuil en ligne. Les discours funéraires à l'ère du numérique* coordonné par Marie-Laure Florea et Adeline Wrona ou encore le numéro 46 *Les discours des institutions pénales à l'épreuve du numérique* coordonné par Isabelle Huré, Guillaume Le Saulnier et Michaël Meyer.



Semen est présente sur openedition depuis 2007.

Historique

Éditée aux Presses universitaires de Franche-Comté (collection Annales Littéraires), *Semen* a été fondée en 1983 et a été soutenue par le GRELIS puis le LASELDI et aujourd'hui ELLIADD. Semen était initialement une publication de laboratoire ; l'équipe éditoriale qui l'a dotée d'un fonctionnement régulier de revue et a renouvelé son comité scientifique à partir de 2000, a souhaité mettre cette revue au service de la communauté. À partir de 2011, cette orientation est encore affirmée par l'élargissement du comité éditorial et l'instauration d'un comité de lecture, qui ouvrent le pilotage de la revue à des chercheurs de renom reflétant le dynamisme et la diversité des domaines concernés par l'analyse des textes et des discours, et étendent le réseau de collaborateurs potentiels et de lecteurs de la revue.

Semen est publiée sous format papier et en ligne.



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Directrice adjointe de la Rédaction

Semen est une revue de sciences du langage qui propose un espace de réflexion sur le(s) discours, en dialogue avec les sciences humaines et sociales et particulièrement avec les sciences de l'information et de la communication.

Semen, revue de sémiolinguistique des textes et discours, pose un **espace de dialogue et de réflexion, dans le champ des sciences du langage**. Les relations de l'analyse du discours, de la linguistique textuelle, de la sémiotique avec différentes disciplines des sciences humaines et sociales connexes telles que la psychanalyse, la philosophie, la sociologie, sont prises en compte, ainsi que les relations avec les sciences de l'information et de la communication. Les problématiques de la textualité et de la discursivité, les relations interdiscursives et intersémiotiques, la perspective de la réception et de l'interprétation, la dimension sociale et idéologique des discours, l'élaboration d'outils d'analyse, les modalités de la construction du sens, constituent des pôles d'intérêt constants.

Semen se compose d'un comité de rédaction, d'un comité éditorial, et d'un comité de lecture.

Le **comité de rédaction** est situé à l'université de Franche Comté, à Besançon.

Il est composé de six enseignantes chercheuses : Andrée Chauvin Vileno, Séverine Equoy Hutin, Marion Bendinelli, Sandra Nossik, Ida Hekmat, Justine Simon. Ce comité gère le quotidien de la revue, assure le suivi administratif et éditorial des numéros, s'assure du bon déroulement de la chaîne d'édition en collaboration avec les coordinateur·ices de chaque numéro et le secrétariat d'édition des Annales Littéraires. Le comité de rédaction assure aussi la mise à jour des informations concernant la revue sur [openedition](http://openedition.org). Il se réunit 4 à 5 fois par an.

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Il est force de proposition et valide les propositions de dossiers thématiques par l'intermédiaire du comité de rédaction. Il s'assure du respect de la ligne éditoriale de la revue. Il se réunit 2 à 3 fois l'an.

Les **comités scientifiques et de lecture** rassemblent une solide communauté de chercheurs reconnus dans les domaines et disciplines ciblées par la revue (Sciences du langage et Sciences de l'Information et de la Communication). Ils constituent la caution scientifique de la revue. Les membres de ces deux comités peuvent être sollicités pour l'expertise d'articles. Ils viennent d'être fusionnés sur décision du comité éditorial.

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Comité scientifique de Semen au 31 décembre 2021

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Politique de publication

La revue fonctionne sur **appel à contribution permanent** pour les **dossiers thématiques**.

Chaque dossier est pris en charge par un.e ou deux coordonnateur.rice.s qui en assure.nt la responsabilité scientifique. Le dossier thématique est construit sur 5 à 6 contributions de 40 à 45 000 signes (espaces et notes comprises). Les coordonnateur.trice.s peuvent intégrer dans ce dossier thématique, s'il(s)ou/et elle(s) le jugent utile, des entretiens, des dossiers bibliographiques, des notes de lecture critique, etc.

Les articles sont publiés en français et sont accompagnés d'un résumé en français, en anglais et de cinq mots-clés dans les deux langues.

La **rubrique « Actualités scientifiques »** ouvre un appel à contribution permanent en vue d’accueillir des textes de formes variées : articles varia ; compte-rendus analytiques et critiques de publications ; entretiens avec des chercheur.es sur des travaux ou bien des thèmes d’actualité ; textes de réaction à l’actualité rendant compte de problématiques scientifiques, disciplinaires ou sociétales ; textes portant sur des œuvres artistiques récentes en lien avec les domaines de prédilection de *Semen*.

Les articles des dossiers scientifiques et de la rubriques Actualités scientifiques font l’objet d’une **expertise des articles en double aveugle**.

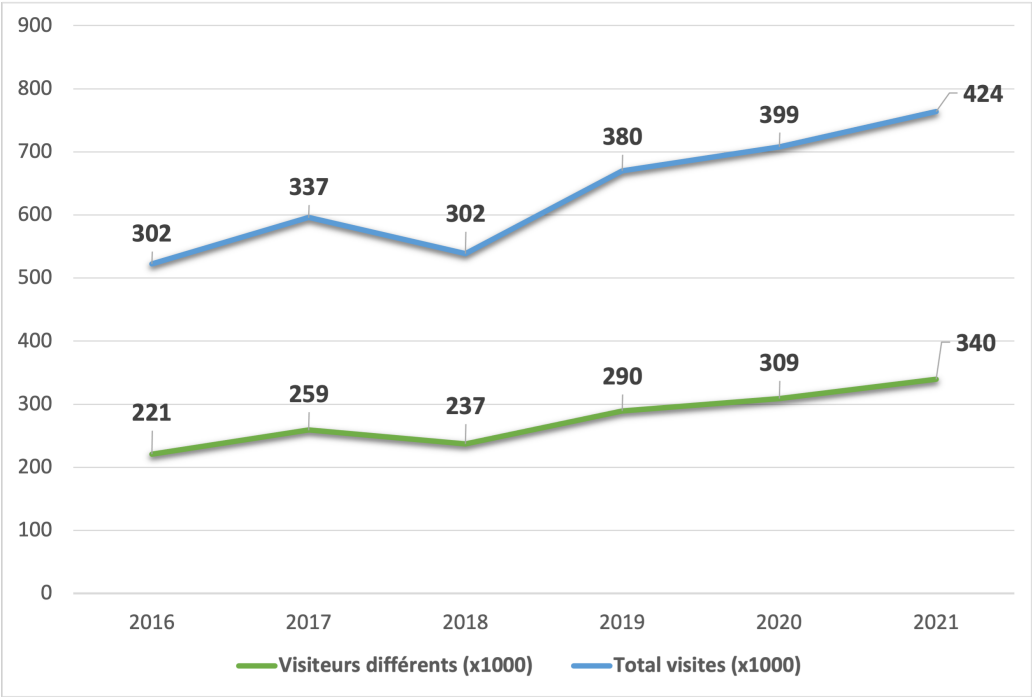
il est important de souligner que la revue bénéficie d’une renommée et d’une audience internationales : la communauté des lecteurs de *Semen* dépasse les frontières hexagonales. En témoignent les données recueillies sur *openedition* :

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(coord. C. Moïse et A. Oprea)

N°41 L'énonciation éditoriale
(coord. M. Arabyan)



2017

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(coord. J. Simon)

N°43 Les rituels politiques
(coord. Jean-Marc Leblanc et Loïse Bilat)



2018

N°44 Le genre, lieu discursif de l'hétérogène
(coord. Julie Abbou, Aron Arnold et Noémie Marignier)

**N°45 Deuil en ligne.
Les discours funéraires à l'ère du numérique**
(coord. Marie-Laure Florea, Adeline Wrona)



2019

N°46 Le discours des institutions pénales à l'épreuve du numérique
(coord. Isabelle Huré, Guillaume Le Saulnier, Michaël Meyer)

N°47 Discours de haine dissimulée, discours alternatifs et contre-discours
(coord. F. Baider et M. Constantinou)



2020

N°48 Les acteurs et actrices du discours
(coord. J. Aboussier, V. Lethier et S. Nossik)

N°49 Signifiant et matière : l'iconicité et la plasticité au prisme du document numérique verbal et visuel
(coord. M. Colas-Blaise, M G. Dondero)



2021

Numéro anniversaire en 2 volets :



**50/1 Sources, itinéraires et prolongements.
Regard(s) sur le parcours de Semen**
(coord. Marion Bendinelli et S. Equoy Hutin)

**50/2 Le langage engagé. Perspectives
politiques critiques en sciences sociales du
langage**
(coord. R Guedj, M. Him-Aquilli et S. Nossik)



Journée *Printemps de Semen*, 25 mars 2022

Le numéro anniversaire n°50 est un numéro double (50/1 paru en décembre 2021 et 50/2 paru en avril 2022) : Il a donné lieu à une journée scientifique de présentation le 25 mars 2022, organisée à l'UFR SLHS de Besançon, en présence notamment des participant.es aux deux numéros et particulièrement de Ruth Amossy (Université de Tel Aviv), Jürgen Siess (Université de Caen) et Marc Bonhomme (Université de Berne) et des membres du comité éditorial et de rédaction.

La journée a été introduite par Jean-Paul Barrière, Directeur des Presses Universitaires de Franche Comté. La journée s'est articulée autour de trois tables rondes :

- 1) Nouveaux paradigmes épistémologiques pour des savoirs situés
- 2) Pratiques d'écriture, frontières disciplinaires, normes
- 3) Revues et édition scientifique en contexte néo-libéral



Affiche et photos de la journée de présentation du numéro 50.



Audience et renommée de la revue

La revue *Semen* bénéficie d'une audience à progression constante depuis 2007 :

Statistiques pour Semen[®] du Mars2022

Dernière mise à jour le **Vendredi 1st Avril 2022 à 09:21** (il y a 6h13mins). Un total de **35,321** visiteurs (dont 28,723 unique) ce mois, une moyenne de **1,139.4** par jour (soit 926.5 visiteurs uniques).

[Ce mois](#) [Tous les mois](#) [Heures](#) [Navigateurs](#) [Pays](#) [Type de fichier](#) [Système d'exploitation](#) [Pages](#) [Referrers](#) [Robot d'indexation](#) [Searches](#) [Sessions](#) [Statut](#)

Visiteurs par années

[Visiteurs par mois](#) | [Visiteurs par années](#)

Année	Nombre total de visites	Visites par jour	Visiteurs uniques	Taux de fidélité	Pages	Hits	BP
2022	105,700	1,779.8	85,192	81%	153,554	153,727	7.6G
2021	424,466	1,162.9	339,590	80%	597,116	597,734	29.0G
2020	398,962	1,090.1	308,630	77%	1,085,475	1,086,095	50.3G
2019	380,118	1,041.4	289,558	76%	764,026	764,895	21.5G
2018	301,561	826.2	237,149	79%	483,713	484,090	15.6G
2017	336,886	923.0	258,899	77%	538,583	538,944	14.8G
2016	301,868	824.8	220,534	73%	479,039	479,239	13.2G
2015	327,025	896.0	218,700	67%	554,296	1,191,184	19.4G
2014	269,321	737.9	183,072	68%	469,151	4,930,876	53.7G
2013	281,635	771.6	193,180	69%	485,892	5,286,048	51.0G
2012	251,325	686.7	173,713	69%	591,356	4,670,250	38.6G
2011	188,344	516.0	134,399	71%	483,281	3,992,464	32.4G
2010	179,279	491.2	128,211	72%	347,835	3,429,027	24.1G
2009	191,483	524.6	149,733	78%	361,874	4,995,533	38.9G
2008	181,748	496.6	147,163	81%	342,826	5,973,829	42.8G
2007	76,616	312.7	62,826	82%	162,977	2,099,670	14.1G
	4,196,337		3,130,549		7,900,994	40,673,605	467.1G

Propulsé par AWStats. Embelli par JAWStats Analyses et Statistiques Web.

Statistiques visiteurs par année depuis 2007.

Source : lodel, accès réservé (consulté le 1^{er} avril 2022)

Sur la période 2016-2021, *Semen* totalise entre 220.534 et 339.590 vues par an (trafic vu) :

Semen

Dernière mise à jour: 01 Avr 2022 - 09:21

Période d'analyse: (2021)

Résumé

Période d'analyse	Année 2021				
Première visite	01 Jan 2021 - 00:11				
Dernière visite	31 Déc 2021 - 23:52				
	Visiteurs différents	Visites	Pages	Hits	Bande passante
Trafic 'vu' *	424 466	424 466	597 116	597 734	28.98 Go
	Valeur exacte Indisponible en vue "annuelle"	(1.24 visites/visiteur)	(1.4 Pages/Visite)	(1.4 Hits/Visite)	(71.59 Ko/Visite)
Trafic 'non vu' *			594 396	594 467	16.55 Go

* Le trafic 'non vu' est le trafic généré par les robots, vers ou réponses HTTP avec code retour spécial.

Dernière mise à jour: 01 Avr 2022 - 09:21

Période d'analyse: - Année - 2020 OK

Résumé

Période d'analyse	Année 2020				
Première visite	01 Jan 2020 - 00:06				
Dernière visite	31 Déc 2020 - 23:55				
	Visiteurs différents	Visites	Pages	Hits	Bande passante
Trafic 'vu' *	<= 308 630 Valeur exacte indisponible en vue 'annuelle'	398 962 (1.29 visites/visiteur)	1 085 475 (2.72 Pages/Visite)	1 086 095 (2.72 Hits/Visite)	50.32 Go (132.26 Ko/Visite)
Trafic 'non vu' *			406 893	406 986	9.59 Go

* Le trafic 'non vu' est le trafic généré par les robots, vers ou réponses HTTP avec code retour spécial.

Dernière mise à jour: 01 Avr 2022 - 09:21

Période d'analyse: - Année - 2019 OK

Résumé

Période d'analyse	Année 2019				
Première visite	01 Jan 2019 - 00:06				
Dernière visite	31 Déc 2019 - 23:50				
	Visiteurs différents	Visites	Pages	Hits	Bande passante
Trafic 'vu' *	<= 289 558 Valeur exacte indisponible en vue 'annuelle'	380 118 (1.31 visites/visiteur)	764 026 (2 Pages/Visite)	764 895 (2.01 Hits/Visite)	21.55 Go (59.43 Ko/Visite)
Trafic 'non vu' *			375 801	375 856	7.53 Go

* Le trafic 'non vu' est le trafic généré par les robots, vers ou réponses HTTP avec code retour spécial.

Dernière mise à jour: 01 Avr 2022 - 09:21

Période d'analyse: - Année - 2018 OK

Résumé

Période d'analyse	Année 2018				
Première visite	01 Jan 2018 - 00:15				
Dernière visite	31 Déc 2018 - 23:48				
	Visiteurs différents	Visites	Pages	Hits	Bande passante
Trafic 'vu' *	<= 237 149 Valeur exacte indisponible en vue 'annuelle'	301 561 (1.27 visites/visiteur)	483 713 (1.6 Pages/Visite)	484 090 (1.6 Hits/Visite)	15.57 Go (54.13 Ko/Visite)
Trafic 'non vu' *			605 256	605 312	9.94 Go

* Le trafic 'non vu' est le trafic généré par les robots, vers ou réponses HTTP avec code retour spécial.

Dernière mise à jour: 01 Avr 2022 - 09:21

Période d'analyse: - Année - 2017 OK

Résumé

Période d'analyse	Année 2017				
Première visite	01 Jan 2017 - 00:00				
Dernière visite	31 Déc 2017 - 23:58				
	Visiteurs différents	Visites	Pages	Hits	Bande passante
Trafic 'vu' *	<= 258 899 Valeur exacte indisponible en vue 'annuelle'	336 886 (1.3 visites/visiteur)	538 583 (1.59 Pages/Visite)	538 944 (1.59 Hits/Visite)	14.84 Go (46.19 Ko/Visite)
Trafic 'non vu' *			1 004 330	1 004 418	18.25 Go

* Le trafic 'non vu' est le trafic généré par les robots, vers ou réponses HTTP avec code retour spécial.

Dernière mise à jour: 01 Avr 2022 - 09:21

Période d'analyse: - Année - 2016 OK

Résumé

Période d'analyse	Année 2016				
Première visite	01 Jan 2016 - 00:03				
Dernière visite	31 Déc 2016 - 23:59				
	Visiteurs différents	Visites	Pages	Hits	Bande passante
Trafic 'vu' *	<= 220 534 Valeur exacte indisponible en vue 'annuelle'	301 868 (1.36 visites/visiteur)	479 039 (1.58 Pages/Visite)	479 239 (1.58 Hits/Visite)	13.16 Go (45.71 Ko/Visite)
Trafic 'non vu' *			919 461	919 511	11.31 Go

* Le trafic 'non vu' est le trafic généré par les robots, vers ou réponses HTTP avec code retour spécial.

Statistiques de consultation, période 2016-2021.
Source : lodel, accès réservé (consulté le 1^{er} avril 2022)

Concernant les ventes (sur place ou sur internet via les PUFC ou FMSH Diffusion), *Semen* s’est écoulé à 70 exemplaires depuis 2017 (hors consultations en ligne *via openedition*). Les ventes via le diffuseur FMSH Diffusion (librairie et site LCDPU) sont en progression : ainsi les numéros 47, 48, et 49 se sont écoulés respectivement à 35, 24 et 33 exemplaires (toujours hors consultations en ligne *via openedition*).

Portfolio N° 5/13

ELLIADD



Dictionnaire de l'Opéra de Paris sous l'Ancien régime



Une recherche et une publication exceptionnelles

Le Dictionnaire de l'Opéra de Paris sous l'Ancien Régime (1669-1791) vient combler les lacunes des grands dictionnaires et encyclopédies anglo-saxons du xx^e siècle (*New Grove*, *New Grove Opera*, etc.). Il éclaire, sur une durée de 120 ans, la vie de la plus importante des institutions culturelles françaises, son répertoire, ses créateurs (compositeurs, librettistes, maîtres de ballets, costumiers, décorateurs, machinistes), son personnel artistique, son personnel administratif.

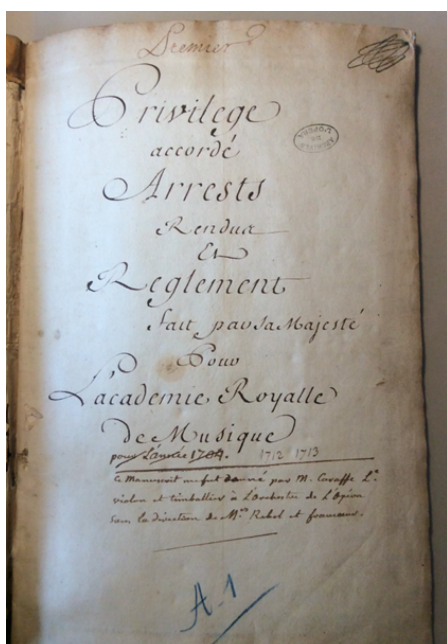
Il a été porté par trois co-directeurs soutenus par trois institutions partenaires : Sylvie Bouissou pour le CNRS, Pascal Denécheau pour le Ministère de la Culture, France Marchal-Ninosque pour l'Université française (UFC, ELLIADD et MSHE).



Un dictionnaire encyclopédique

Pour la première fois dans l'Histoire, l'intégralité des productions de l'Opéra de Paris est recensée et traitée. Les articles consacrés aux œuvres livrent de nombreuses informations concernant la création et les reprises, la distribution de la création, le synopsis, les sources littéraires, un commentaire littéraire et musical et une étude de la réception. Grâce au dépouillement de milliers de documents d'archives et de toute la presse des xvii^e et xviii^e siècles, la liste exhaustive du personnel de l'Opéra a été également dressée avec, pour chaque interprète, une biographie. Enfin les articles consacrés aux notions rassemblent l'état actuel des connaissances en lien avec le répertoire, le personnel et les pratiques institutionnelles.

L'encyclopédie totalise 7 322 entrées, donnant chacune lieu à la rédaction d'un article établi selon des nomenclatures strictes. La publication du *Dictionnaire* (2019-2020) totalise 11 millions de signes pour plus de 4 000 pages. Cinquante-trois collaborateurs y ont participé (France, UK, Italie, USA, Allemagne, Pays-Bas), spécialistes de musicologie, d'histoire de la danse, d'histoire littéraire, d'histoire des institutions et d'histoire des arts.



ACTEURS ET ACTRICES CHANTANS DANS LES CHŒURS.

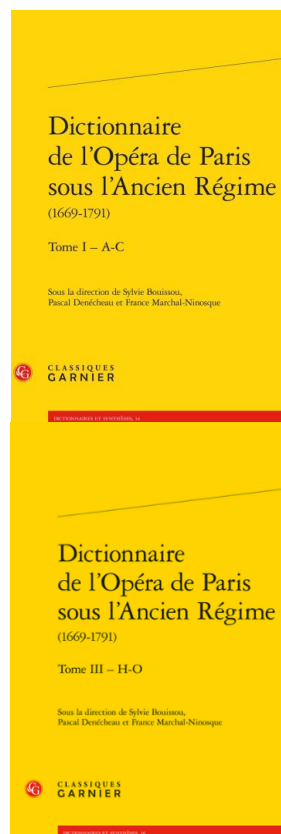
CÔTÉ DE LA REINE <i>Mesdemoiselles. Messieurs.</i>		CÔTÉ DU ROI. <i>Mesdemoiselles. Messieurs.</i>	
des Rosières.	Candeille.	Dubuisson.	Peré.
Veron.	Capoi.	Garrus.	Le Grand.
d'Hauterive.	Larlat.	Rouxelin.	Martin.
Thaumat.	Rey.	Sanctus.	Pouffez.
Josephine.	Punchar.	Charmoy.	Firmin.
Fel.	Vallon.	Leclerc.	Huet.
Launer.	Méon.	Des Lions.	Itasse.
Macker.	Cleret.	Le Bœuf.	Jouve.
Aurore.	Tacuset.		Moulin.
David.	Baillon.	Voisin.	Jalaguier.
	de Lori.		Cavallier.
	Fagnan.		Bouvard.
	Joinville.		Martin, c.
	Le Roux.		

Aij

La publication

Le projet a été construit de 2012 à 2020 avec, en accompagnement, la publication de *La Lettre du Dictionnaire de l'Opéra de Paris (1669-1791)*. Outre l'aide financière et technologique apportée par ELLIADD, il a bénéficié d'un large soutien financier et institutionnel du Ministère de la culture, de l'UMR 8223 (Iremus), de la MSHE (Ledoux), et du FIR de Paris IV Sorbonne (ED et Iremus).

L'ouvrage a été présenté à la communauté internationale rassemblée pour le *Congrès Tosca* dans le Grand Amphithéâtre de l'Opéra Bastille, à l'occasion du 350^e anniversaire de l'Opéra de Paris, en juin 2019. Il fait l'objet de comptes rendus élogieux dans des revues internationales (*Danza et Ricerca*, Italie, *Dance Research Journal*, USA...).





Using Digital and physical simulation to focus on human factors and ergonomics in aviation maintainability

Auteurs

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Contexte

L'entreprise Airbus Helicopters se situe sur l'aéroport de Marignane (13), elle est un des leaders mondiaux dans la construction et la vente d'hélicoptères. Le site de Marignane est composé d'un peu plus de 10 000 employés et a pour objectif d'imaginer, développer, construire, tester et livrer des hélicoptères. Ces travaux de recherche dans un cadre d'une thèse CIFRE se sont réalisés au sein du département « maintenabilité », entité du bureau d'études étudiant et anticipant la maintenance des hélicoptères en développement et en améliorant celle de ceux déjà livrés. Les travaux de recherche ont été motivés par deux éléments principaux :

- Le premier élément provient du constat des clients où la maintenance reste complexe avec un taux d'indisponibilité parfois élevé, pouvant dépasser 5 heures de maintenance par heure de vol. Un des leviers d'amélioration est donc la réduction de la complexité des tâches de maintenance et de la durée de cette activité. Dans ce cadre, les travaux du laboratoire ELLIADD, en intégrant l'ergonomie dans le processus de conception en maintenabilité, supposent qu'une conception anthropocentrée devrait pouvoir, à minima, faciliter l'activité de maintenance et améliorer la sécurité.
- Le deuxième élément provient de l'intérêt d'une démarche ergonomique pour résoudre des problématiques liées à l'usage des outils numériques. Le département a, dès lors, considéré le facteur humain comme une voie possible d'amélioration qu'il est nécessaire d'explorer et d'étudier dans son ensemble, car permettant de l'articuler avec les exigences techniques. En particulier, l'amélioration de l'usage des outils de simulation numériques et physiques actuellement mis en place et qui a intéressé le département.

Ainsi, l'objectif de cette thèse qui est menée entre le laboratoire de recherche ELLIADD et la compagnie AIRBUS HELICOPTERS était d'intégrer le facteur humain dans le processus de conception au sein du département de maintenabilité.

Problématique de l'article

L'exploitation et l'usage des outils de simulation pour évaluer l'ergonomie varient en fonction du contexte et de l'outil en lui-même puisque plusieurs technologies existent. La première étude réalisée dans le cadre de cette thèse¹ a montré que l'usage des outils de simulation par les acteurs-métiers du département de maintenabilité de l'entreprise aéronautique pilote, ne permet pas de réaliser des analyses exhaustives relatives au facteur humain. En effet, seule la composante physique de l'ergonomie est étudiée, quel que soit l'outil de simulation utilisé, alors que les composantes cognitives et organisationnelles devraient être également prises en compte afin de bien tenir compte des caractéristiques, des attentes et des besoins des personnes, en l'occurrence les opérateurs dédiés à la maintenance. Ainsi, il ressort que le manque de connaissances en facteur humain des acteurs-métiers en maintenabilité pourrait induire une sous-exploitation des outils de simulation lorsqu'il s'agit de les utiliser à des fins d'analyses ergonomiques. De plus, le facteur humain est étudié de manière très disparate dans chacune des phases d'étude qui compose le processus de conception en maintenabilité. Afin de bien comprendre les pratiques actuelles et les éventuelles limites dans l'usage des outils de simulation, nous aurions ainsi pu suivre des études en cours dans le département de maintenabilité dont l'analyse du facteur humain est supportée par un outil de simulation. Ainsi, l'apport de chacun des outils de simulation (mannequin numérique, réalité virtuelle et maquette physique) pour réaliser des analyses en facteur humain à travers un protocole expérimental dédié. Dans ce cadre, nous avons décidé d'étudier sur un même hélicoptère, 11 tâches de maintenance récurrentes et représentatives des tâches habituelles en termes de difficulté, de posture, de complexité... avec la participation d'opérateurs réels de maintenance.

La revue Human Factors

La revue Human Factors est un journal international dans le domaine des facteurs humains/ergonomie qui présentent des avancées théoriques et pratiques concernant la relation entre les personnes et les technologies, outils, environnements et systèmes. Il s'agit de la revue phare de la Société américaine des facteurs humains et de l'ergonomie, qui a publié son premier numéro en 1958 sur la plateforme SAGE. L'impact facteur de ce journal est de 2.888 et 4.173 sur 5ans le plaçant parmi la meilleure revue dans le domaine de l'ergonomie.

Visibilité/Citation

Selon la plateforme Google Scholar, cet article a été cité 18 fois depuis sa publication. Le site web Human Factors indique que cet article a été téléchargé 3196 fois jusqu'au 13/5/2022.

¹ Bernard, F., Zare, M., Sagot, J. C., & Paquin, R. (2019). Integration of human factors into the design process of helicopter maintainability. Human Factors and Ergonomics in Manufacturing & Service Industries, 29(4), 350-360.

SPECIAL SECTION: 2018 IEA Congress

Using Digital and Physical Simulation to Focus on Human Factors and Ergonomics in Aviation Maintainability

Fabien Bernard^{ID}, Airbus, Marignane, France and University of Technology of Belfort-Montbéliard–University of Bourgogne Franche-Comté, France, **Mohsen Zare**, **Jean-Claude Sagot**, University of Technology of Belfort-Montbéliard–University of Bourgogne Franche-Comté, France, and **Raphael Paquin**, Airbus, Marignane, France

Objective: This research aimed to evaluate the differences in the assessments made by three simulation tools used in a maintainability design office to perform human factor/ergonomics (HFE) analysis: digital human modeling (DHM), virtual reality (VR), and physical mock-up (PMU).

Background: Maintainability engineers use digital/physical simulation tools in the early design phase to analyze whether the design is well adapted for maintenance operators. Knowing the potential of these simulation tools would encourage maintainability stakeholders to integrate HFE in the design process more efficiently.

Method: Eleven maintenance tasks were analyzed from the participation of six maintenance operators. Various HFE indicators including physical, cognitive, and organizational indicators were assessed. Each operator repeated 11 maintenance tasks on VR and PMU. Based on the anthropometric parameters, six manikins were created to analyze 11 maintenance tasks on DHM.

Results: A significant difference was found for the organizational indicators between VR and PMU, whereas the physical and cognitive indicators are similar. DHM, VR, and PMU are compared with the common HFE indicators for the physical dimension and present a significant difference for individual tasks.

Conclusion: To reduce the gap between simulation tools, a better physical representation is requested on the VR platform, improving the perception of work sequences in the virtual world. Concerning DHM, a new paradigm is proposed to study a few tasks per work area instead of studying each task independently.

Application: This study will help develop a new methodology and tools specifically for non-HFE experts in the maintainability department.

Keywords: human factors, ergonomics, simulation tools, virtual reality, physical mock-up, maintainability, aeronautics

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INTRODUCTION

Human Factors in Maintenance

Human performance has been studied from the very beginning in the aviation field, especially regarding aircraft accidents (Maurino, Reason, Johnston, & Lee, 2017; Wiener & Nagel, 1988). Initially, the reliability of machines was the primary concern, and many attempts were made to improve the technology of the devices (Maurino et al., 2017; Wiener & Nagel, 1988). During the following decades, human factors/ergonomics (HFE) raised as a discipline to design the flight deck and to investigate the interaction between human (pilot) and machine, particularly, during the training phase of the pilot in a simulator (Horeman, Akhtar, & Tuijthof, 2015; Wiener & Nagel, 1988). Safety and comfort in the cockpit and the passenger cabin were also improved by considering HFE principles during the subsequent decades (Spenser, 2008). However, 12% of all aviation accidents were due to HFE issues during maintenance activity (Hobbs, 2000). Integrating HFE in maintainability may increase the quality of maintenance activities and reduce the rate of mistakes/errors (Gruber, De Leon, George, & Thompson, 2015). The design engineers in the maintainability department interact and collaborate with other engineering departments (e.g., aerodynamic, hydraulic and electric integration, and architecture), and raising HFE culture between them could effectively affect the future maintenance activity.

However, aviation accidents are not the only problem that demonstrates the need to improve HFE for maintenance activities. The health and safety of maintenance operators is also a key

contributor to maintenance errors (Hobbs, 2000). Various studies have already highlighted the fact that maintenance activities can cause health problems (musculoskeletal disorders, stress, and high mental workload) and workplace accidents (French Association of Maintenance Engineers (AFIM; 2004; European Agency for Safety and Health at Work, 2010). In a survey of 2,500 maintenance operators from various industries (automotive, train, and aeronautics), AFIM showed that 62% of respondents considered their occupation to be dangerous. Another study performed in Europe showed that 15%–20% of accidents at work occurred in the field of maintenance, suggesting that maintenance tasks are the most dangerous activities in an industry (European Agency for Safety and Health at Work, 2010).

Simulation Tools for Assessing Human Factors

The design engineers simulate the maintenance activities in the digital mock-up (DMU) and physical mock-up (PMU) to integrate HFE in the design process of maintainability in the early design phase (Stoffregen, Bardy, Smart, & Pagulayan, 2003). They proactively analyze the future maintenance activity, either in a DMU or in a PMU, by different ergonomic tools. The DMU can be categorized into two simulation tools: digital human modeling (DHM) and virtual reality (VR). DHM allows the integration of ergonomics in the preliminary phases of the design process of the product, manufacturing, and maintenance (Ahmed, Gawand, Irshad, & Demirel, 2018; Krüger & Nguyen, 2015; Perez, de Looze, Bosch, & Neumann, 2014). Various types of DHM tools have been developed. Rasmussen, Damsgaard, Christensen, and Surma (2002) presented the AnyBody digital manikin, which aims to couple the specific geometric criteria of a future product with the ergonomic requirements of a multidisciplinary optimization approach. Jack manikins (EAI-UGS) have been used in various industries to evaluate HFE indicators (disassembly, accessibility, usability) on maintenance tasks (Di Gironimo, Monacelli, & Patalano, 2004). The Human Builder is the most frequently used manikin tool in the aviation field and presents various useful characteristics

(visual fields, posture analysis, anthropometric measurements, and biomechanical single action analysis) for maintainability studies (Hashim, Kamat, Halim, & Othman, 2014; Nishanth, Muthukumar, & Arivanantham, 2015). Geng, Zhou, Lv, and Wang (2013) propose a methodology to improve the use of ergonomics options for the human builder to anticipate the risks of maintenance activities on the auxiliary power unit of a plane. According to these authors, the visual field, reach envelope, and the rapid upper limb assessment (RULA) score are the existing options for studying the manikin's interactions with its environment in maintainability. Another study attempts to assess the occupational risks of the semiautomatic pump manufacturing industry using the human builder (Nishanth et al., 2015). However, DHM cannot anticipate the full activity of the real operators, and it is difficult to make decisions and validate the design based solely on DHM. Quintero-Duran and Paul (2016) explain the limitations of using DHM during the design development stage. These authors highlight the fact that the influence of design on the human's behavior cannot be simulated and anticipated with DHM studies. It is also not possible to observe psychosocial and environmental stressors, which presents a limitation in the study of human factors using DHM. Johnson and Fletcher (2015) have detailed the subjectivity of human factor analysis with DHM because the manikins' degrees of freedom are not always representative.

For this reason, VR is used—as a typical DMU tool—to study the operator's accessibility and the interaction with the architecture, particularly in maintainability (Amundarain, Borro, Matey, Alonso, & de Guipúzcoa, 2003). VR is easy to edit and cost-effective, and the aviation industry uses it to evaluate the ergonomic features of a task, whereas PMU is less predominant when simulating maintenance tasks (Shi & Liu, 2012). The virtual setting is not sufficient to consider all aspects of HFE in the design process, and PMU is utilized to design space forms and architectural aesthetic. However, this design approach is technocentric design (more focused on technology) whereas the anthropocentered design (interactions between operators and the architecture) might be more suitable, which will

consider organization, mental processes (e.g., perception, reasoning), and motor responses (Bittencourt, Duarte, & Béguin, 2017; Czerniak, Brandl, & Mertens, 2017; Das & Sengupta, 1996; Meister, 2014; Sagot, 1999).

The background/experience of the engineers allowed them to focus almost entirely on the physical dimension of HFE (Bernard, Bazzaro, Paquin, & Sagot, 2017; Bernard, Zare, Sagot, & Paquin, 2019; Broberg, 2007). The maintainability engineers may underutilize the potential of DMU and PMU for performing ergonomic analyses on simulated maintenance tasks due to their lack of HFE skills and knowledge (Sharma, Singhal, & Sonia, 2018). Few studies have investigated the contribution made by DMU and PMU to the design process, and more specifically, the complementary aspect of VR and PMU. Although various DHM tools have already been compared in previous studies (Duffy, 2016; Lämkkull, Hanson, & Örtengren, 2009) there is very little literature concerning the contribution of DHM, VR, and PMU during the design process (Pontonnier, Dumont, Samani, Madeleine, & Badawi, 2014). Recent studies have demonstrated the possibility of applying VR and augmented reality for ergonomic studies in the design process, but they concluded the significant difference between real and virtual settings results (Aromaa & Väänänen, 2016; Pontonnier et al., 2014).

The challenge in the maintainability department of the aeronautical industry is to integrate better HFE, using simulation tools (DHM, DMU, and PMU) during the design phases. We hypothesize that engineers use the simulation tools more efficiently for assessing ergonomic factors when they know the differences and complementary aspects of these tools. The first step in this proposed improvement is to study the existing disparity between the simulation tools. This study was, therefore, designed to investigate the difference in the assessments of HFE indicators made by DHM, VR, and PMU.

THE CONTEXT OF THE STUDY

Maintainability is defined as the ability of a product to be maintained/repared easily during maintenance operations that include the functions for which it was designed (EN 13306:2010,

2010). Maintenance tasks are expensive for the aeronautical industry, reaching between 12% and 15% of an airline's total costs per year (Čokorilo, 2011). Furthermore, the duration of each maintenance task (referred to as the mean time to repair, MTTR) must be respected (Chang & Wang, 2010). The ratio of "hours of maintenance/flight hours" is a priority in the helicopter industry. Maintainability stakeholders must anticipate the future maintenance operator's activities in three main ways: the item's architecture, the operator's tools, and the operator's ways of working (Lee, Ma, Thimm, & Verstraeten, 2008). However, it can be challenging to predict the human activity involved in maintenance for maintainability engineering, mainly by taking customer feedback into account.

More than half of maintenance professionals from various industrial and service sectors interviewed in a survey believed that their occupation is hard (French Association of Maintenance Engineers, AFIM). Health and safety are, therefore, the significant maintenance issues that should be studied further.

To study maintenance activity, we focus our analysis on the upper deck of a helicopter, where the engine is located as illustrated in Figure 1. The maintenance tasks performed on the engine were complicated due to the reduced accessibility and the limited available workspace.

METHOD

Research Setting

The PMU used for our experiment represents the upper deck. The scaffold is created to provide access to the right/left engine for the operators. Figure 2 shows the top view of the upper deck. The maintenance operation is carried out from the corridor of the maintenance scaffolding. The maintenance tasks are carried out on both the left and right sides, depending on the arrangement of the technical elements (asymmetrical tasks). Some tasks must/can be performed through hatches requiring standing, kneeling, or lying postures.

Maintenance Tasks Selected

Eleven maintenance tasks were evaluated on the upper deck (Table 1). We selected these

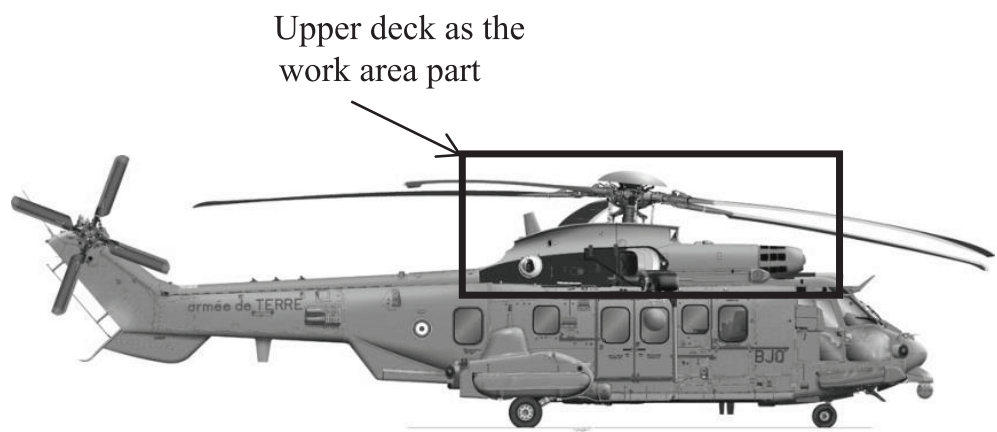


Figure 1. Helicopter representation with the upper deck as the work area.

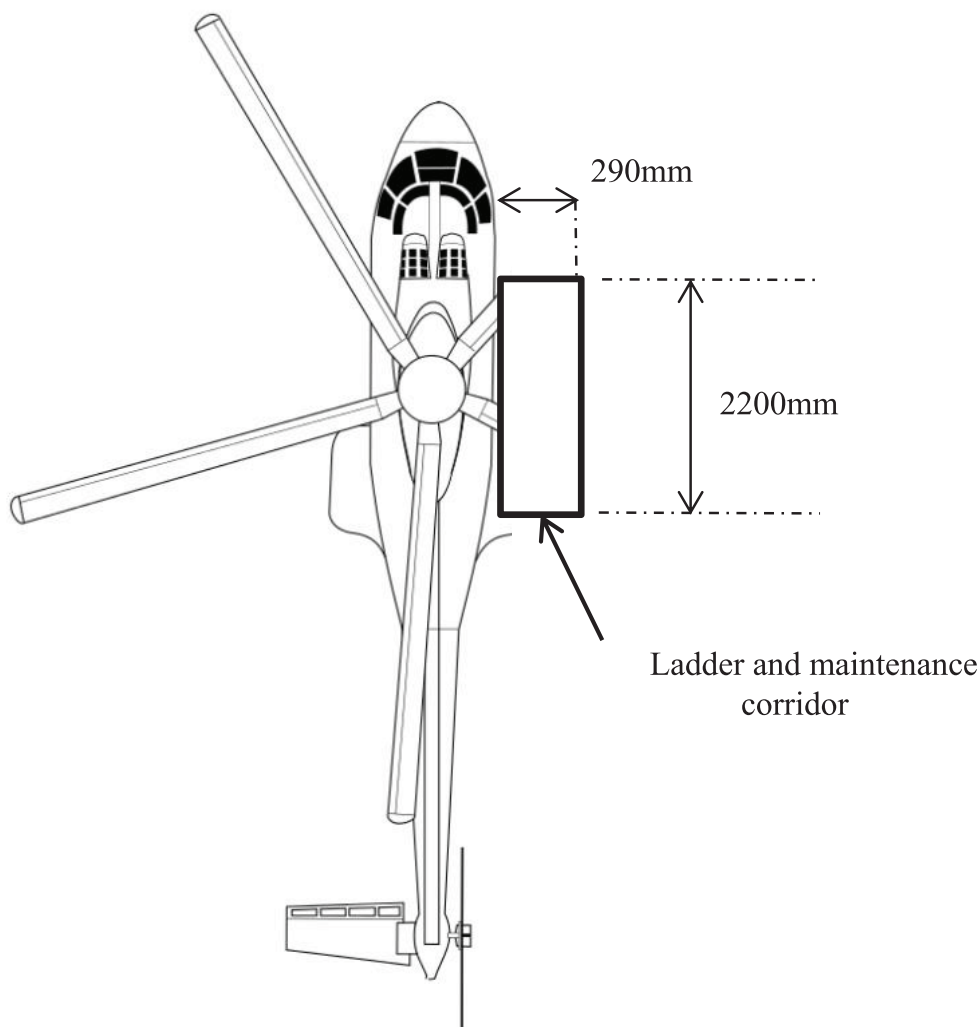


Figure 2. Top view of the upper deck layout with ladder and maintenance corridor on the right side (the same is installed on the left side).

TABLE 1: Description of Each Task and the Main Postures Associated

Task	Description	Main Posture
1	Manipulation of the ladder and upper deck to anchor them	Standing
2	Disassembly/assembly of the main generator	Standing and bending
3	Manipulation of the electric plug behind the firewall	Kneeling
4	Manipulation of engine electric plug (floor)	Kneeling/lying down
5	Disassembly/assembly of the hydraulic pump	Kneeling/standing
6	Verification of the drain collector	Kneeling
7	Disassembly/assembly of the auxiliary generator	Standing and bending
8	Disassembly/assembly of engine support	Lying down
9	Tightness check of the RPM	Kneeling
10	Tightness check of the suspension support	Kneeling
11	Tightness check of the primary rotor actuator	Kneeling

tasks because of their recurrence and representativeness among other maintenance tasks of the helicopter and plane, particularly, regarding the parameters of posture, gestures, and effort. Various studies in the aviation field have confirmed the interest of the engine part in performing HFE analysis (Amundarain et al., 2003; Dmitriev, Burlakov, Popov, & Popov, 2015; Geng et al., 2013), particularly because of the variability of tasks and work postures (Lockett & Arvanitopoulos-Darginis, 2017; Lu, Zhou, & Li, 2015; Shi & Liu, 2012). In addition, the tasks selected in our study are included as part of regular and mandatory maintenance activities—the most frequent task (Task 1), which is performed every week, and the least frequent task (Task 7), which occurs once a month. Furthermore, all the maintenance tasks have a theoretical duration estimated using the mean time measurement (MTM) method (Laring, Forsman, Kadefors, & Örtengren, 2002); this theoretical duration was taken as a reference in our experiment to compare with the real time needed to perform the tasks on VR and PMU.

Specification of Simulation Tools

As the study was conducted in the aerospace industry, we used the “Human Builder” simulation tool, which is already employed by many maintainability engineers in various industries (Geng et al., 2013; Nishanth et al., 2015). The maintainability design engineer performs design analysis with a computer-aided design (CAD) software system (CATIA). This CAD integrates

a DHM that is easily accessible for all design office stakeholders and that gives the option of carrying out ergonomic analyses and validating the design environment. The technical inputs, such as the weight of the manipulated parts and the duration of the tasks, came from other departments of the design office. The maintainability stakeholders performed the simulation with various statures (Figure 3).

The VR technology used by the helicopter manufacturer was realistic human ergonomic analysis (RHEA), and we used this technology for the experiment. The VR is based on “Virtools” software and is included in the design process, allowing a fast transfer between the CAD and VR platform. Real operators performed 11 maintenance tasks simulated in the VR platform. The physical interactions, such as contacts with the architecture of the upper deck, assembling/disassembling elements that represent real volume, the real weight of the components, and the sensors on the components to carry them virtually, were created on VR (Boy, 2018) to synchronize the virtual and real world (Figure 4). We could, therefore, keep the simulation setting as close as possible to the usual process and the current industrial context. The VR platform is composed of a VR headset (Oculus Rift) worn by the operator performing the maintenance tasks. The VR headset view was displayed on the screen, which was shared with the virtual work setting, including the operator’s avatar (reproducing the behavior of the real operator). This output ensures a full

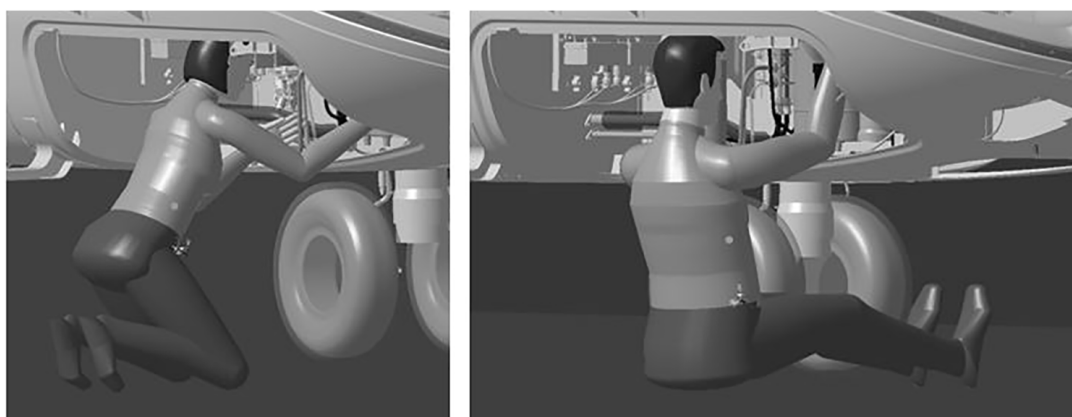


Figure 3. Interaction of the human builder manikin with the environment for the same task: on the left, 5th percentile female and on the right 95th percentile male.

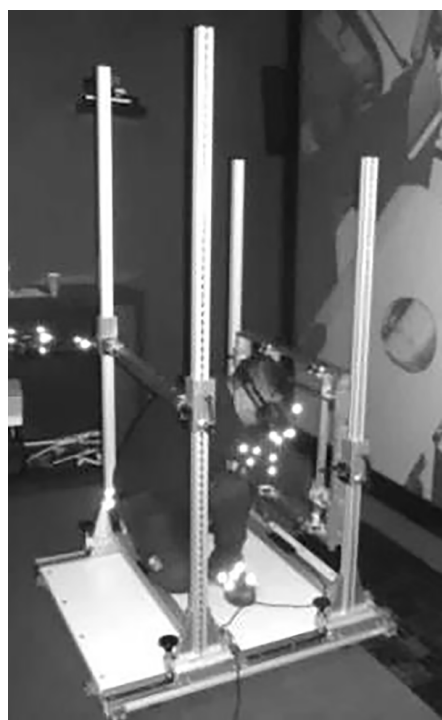


Figure 4. Physical part integrated during the virtual reality simulation.

observation by maintainability stakeholders in the room to correlate the activity of the real operator and the evolution of his or her avatar in the virtual world.

Each operator repeated the same 11 maintenance tasks on the PMU under realistic conditions—reproducing the real weight and center of gravity. The PMU was composed of wooden parts and the real components of the upper deck. The realistic constraints were

reproduced between the mock-up and the maintenance operators: the removable parts (with their real weight and center of gravity), the torque force, and small removable components (screws, nuts) were installed.

Participants and Organization of the Experiment

Six male operators were selected according to the NF EN ISO 15537 (2004) standard “Principles for selecting and using test persons for testing anthropometric aspects of industrial products and designs.” We could not include more operators for our experiment due to the constraints related to industrial maintenance planning and the availability of the simulation tools (VR and PMU). Two main characteristics were considered when selecting the subjects: anthropometric parameters (Table 2) and work experience (knowledge and expertise concerning the maintenance of helicopter engine systems). In addition, informed consent was obtained from each participant and the subjects were informed about the objectives and the methodology of the study. During the VR simulation, one operator (out of six subjects) was only able to complete four of the 11 tasks because he experienced motion sickness.

The experiment started on the PMU, with each of the six operators performing the 11 tasks individually over 2 hr. The same protocol was deployed within the VR platform 6 weeks later. In total, 12 hr of experimentation per simulation tool were analyzed based on direct observation

TABLE 2: The Operator's Characteristics and Anthropometric Measurements Applied to Create the Manikins in the Digital Human Modeling

	Age	Experience		BMI (Kg m ²)	Stature (cm)	Trochanteric Height (cm)	Shoulder Width (cm)	Pelvis Width (cm)	Hand Length (cm)	Hand Width (cm)
		(years)	Weight (Kg)							
Operator 1	42	11	69	25.2	165.5	84	40	31.5	17.2	6.6
Operator 2	31	13	70	24.2	170	80	41.2	33.5	18.3	7.4
Operator 3	52	22	87	27.8	177	90	43	36.5	21.6	7.8
Operator 4	45	24	76	23.9	178.5	95	43	33	19.8	7.8
Operator 5	46	11	82	24.5	183	97	44.3	35.9	20.6	9.6
Operator 6	51	30	105	31.0	184	102	48.4	38.7	19.4	8.6
M (SD)	44.5 (7.6)	18.5 (8.0)	81.5 (13.4)	26.1 (2.8)	176.3 (7.3)	91.3 (8.3)	43.3 (2.9)	34.9 (2.7)	19.5 (1.6)	8.0 (1.0)

TABLE 3: Common HFE Indicators Between DHM, VR, and PMU Related to Maintenance Tasks, and the Measurement Tools Used to Evaluate These Indicators

Indicators	Measurement tools VR and PMU	Measurement tools DHM	Metrics
Posture	Reach envelope (video/photo)	Reach envelope (analysis option)	% (time)
Musculoskeletal symptoms	RULA (Paper version)	RULA (analysis option)	Scale from 1 to 7
	Nordic questionnaire		Neck
			Shoulders
			Upper body
			Elbows
		/	Lumbar
			Wrists/hands
			Hips
			Knees
Effort	Borg (perceived physical exertion)	/	Ankles/feet
Workplace safety	APACT check list (section 9)	APACT check list (section 9)	Scale from 0 to 10
Time	Duration	/	Task duration
Mental workload	NASA-TLX	/	Scale from 0 to 100

Note. HFE = human factors/ergonomics; DHM = digital human modeling; VR = virtual reality; PMU = physical mock-up; RULA = rapid upper limb assessment; APACT = Association for Improvement of Working Conditions; NASA-TLX = National Aeronautics and Space Administration—Task Load Index.

and video recording. To perform the third experiment with DHM, a series of anthropometric parameters were measured on real operators to simulate the digital manikin in a way that reflected the operator. These measurements were carried out based on the NF EN ISO 7250 (2017) standard “Basic human body measurements for technological design.” The six main anthropometric parameters were stature, trochanteric height, shoulder width (bideltoid), pelvis width (seated subject), and the length and width of the hand (Table 2). We used the “posture editor” option in CATIA to set the manikin consistent with the anthropometric dimensions of each body segment and to adjust the angulation of each joint (Hashim et al., 2014; Neumann, 2006).

We can divide our analysis into two parts: comparing two simulation tools by considering six HFE indicators with the participation of the real operators (VR and PMU) and comparing three simulation tools (DHM, VR, and PMU) by

integrating three HFE indicators. Due to the limitation of DHM, it was not possible to assess all aspects of activity without a real operator. The following section will discuss the common HFE indicators and investigation instruments that were used in this study in detail.

The Investigation Instrument

The operator’s activity was analyzed through two frequent maintenance activities that are often studied in maintainability: assembly and disassembly—defined as the capacity for an operator to disassemble and assemble a mechanical system (De Leon, Díaz, Martínez, & Marquez, 2012). We selected six HFE indicators to analyze these activities, which made it possible to cover the majority of HFE dimensions (physical, cognitive, and organizational dimensions) as defined by the International Ergonomics Association (IEA; 2000). The measurement tools used to quantify HFE indicators were as follows (Table 3):

- The reach envelope: we measured the percentage of time it took the operator to reach the maintenance area on VR and PMU. For DHM, the “reach envelope” was analyzed and measured as a percentage of time by estimating the total duration of the task via the MTM method. The DHM proposed an assessment of reach envelope, simulating a virtual envelope around the manikin (Guan, Lei, & Li, 2012; Hashim et al., 2014; Neumann, 2006).
- RULA assesses the upper limbs’ exposure to MSD risks. This method takes into account three main indicators: posture, force, and frequency (McAtamney & Corlett, 1993). This tool measured the postures of the subjects with a paper-based checklist on VR and PMU. The posture assessment option is available in CATIA software and allowed us to evaluate the postures of manikins on DHM (Guan et al., 2012; Vyavahare & Kallurkar, 2015).
- The Borg scale (Borg, 1982) was used to measure perceived exertion during physical activity. Its recent version, CR10, ranging from 0 (*no effort*) to 10 (*very hard*), was used only for the experience on VR and PMU.
- Safety work area: A checklist developed by the Association for Improvement of Working Conditions (called the APACT) is used to evaluate the safety criteria of DMU, VR, and PMU settings (Chitescu et al., 2003). This checklist possesses 22 parameters evaluating the HFE of the workplace in terms of ergonomic standards. Section nine of this checklist, which relates to “work area safety,” was used to assess the potential risks of indicators including working at height, falls, burns, or breaks, by combining the level of personal protection and the integrity of work protection, thus showing us the organizational dimension of the task. The score is ranked from 0 to 10 and considered damaging below 6.5.
- NASA-TLX (Hart & Staveland, 1988) was used to evaluate mental workload. Based on six dimensions (mental demands, physical demands, time requirement, personal performance, frustration, and stress), it provides a final score rated from 0 to 100 that shows the degree of mental workload (low ≤ 30 or high ≥ 30). The operators answered the NASA-TLX questionnaire immediately after performing the simulated task, but only for the experience on VR and PMU.
- Nordic questionnaire (Kuorinka et al., 1987): MSD symptoms were assessed by a body map

questionnaire developed based on the Standardized Nordic questionnaire. This questionnaire was only used for the experiments on VR and PMU.

Statistical Analysis

We used the nonparametric Friedman and Wilcoxon tests because of the small sample size and the dependent variables (same population in three settings). The differences in execution time for performing the 11 maintenance tasks were tested for three variables (the theoretical execution time, the execution time through VR platform, and the PMU setting) using the Friedman test. The common variables (RULA and workplace safety score) for three situations (DHM, VR, and PMU) were also analyzed using the Friedman statistical test. The nonparametric Wilcoxon test was used to compare the indicators for musculoskeletal symptoms, mental workload, and perceived physical exertion on the VR and PMU settings. Statistical analysis was performed in SPSS 24.0 (IBM), and $p < .05$ was considered significant.

RESULTS

Each task performed on both simulation tools (VR and PMU) required an execution time higher than the theoretical time estimated by the MTM method, and this difference was statistically significant for nine tasks (Figure 5). Furthermore, variable execution times were found between VR and PMU. For example, the duration for executing Task 1 was 7.6 (± 0.3) s on the PMU, whereas it was 164.7 (± 12.3) s on the VR platform—much higher than PMU. However, it was opposite for Task 10 as the execution time was 393.2 (± 68.1) s on VR and 168.4 (± 11.3) s on PMU.

We compared the various HFE indicators tested on the simulation tools (VR and PMU) with the participation of real operators. The RULA score and the safety at work score were not significantly different between VR and PMU. The musculoskeletal symptoms in the lower back and knee represented the meaningful percentages felt by the participants. The lower back strain was significantly different between VR and PMU only for Task 8 (Table 4). The percentages of musculoskeletal symptoms were negligible for the other body segments on both

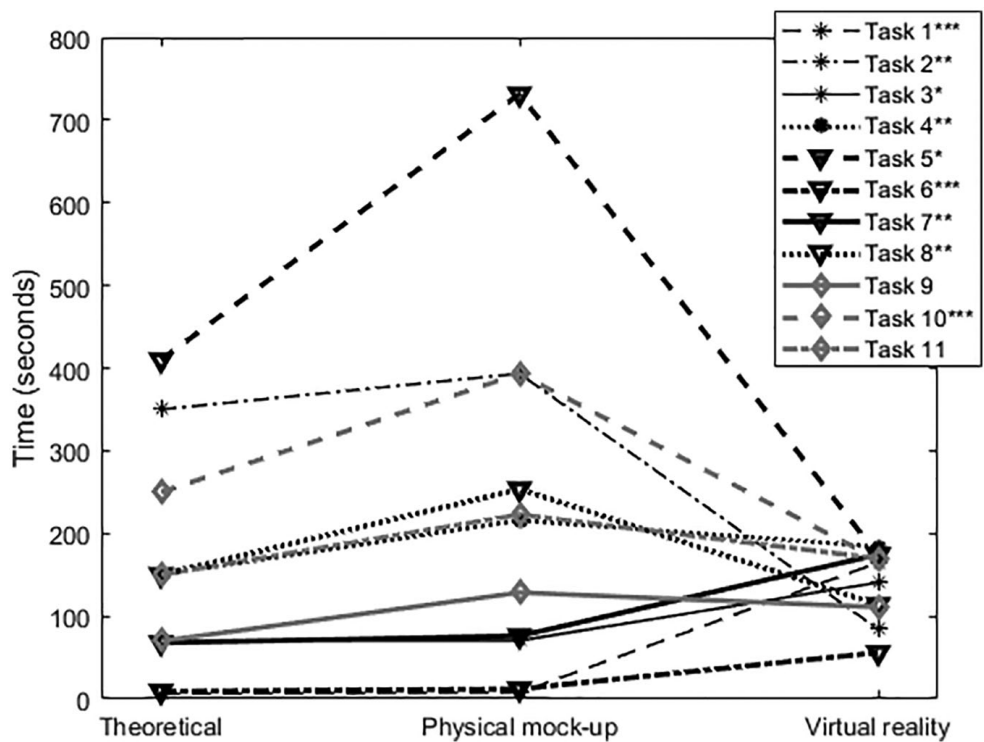


Figure 5. The execution time of 11 aviation maintenance tasks on the physical mock-up (PMU) and virtual reality (VR). The theoretical execution time estimated by the mean time measurement (MTM) method provided for each task (Friedman $*p \leq .05$; $**p \leq .01$; $***p \leq .001$).

simulation tools. Perceived physical exertion (Borg scale) and mental workload (NASA-TLX) were compared in individual tasks with both VR and PMU. The Wilcoxon test showed no significant difference between the results of the Borg scale and NASA-TLX on VR and PMU. However, the NASA-TLX score presented a few differences, and mental workload was higher for VR than for PMU in each task. Tasks 2 and 10 received the highest scores—regardless of simulation tool—due to the excessive time and difficult accessibility associated with a static effort to retain an alternator weighing 18 kg. A long static effort quickly caused pain; the operator was irritated and wanted to accomplish the task as soon as possible, which heightened the mental workload. Tasks 1 (displacement in the engine cowling) and 9 (checking and tightening torque) were the easiest, as 1 required little effort.

Furthermore, the RULA score for each task was compared between DHM, VR, and PMU. Five tasks showed a significant difference in the

RULA score between DHM, VR, and PMU (Table 5). Only Task 8 had a similar score between the three simulation tools (Table 5). Five tasks showed significant differences between the three simulation tools for safety at work parameters (Table 5). For these five tasks (2, 3, 5, 6, and 7), we observed similar characteristics with sufficient space to move the manikin in various postures (Figure 6). However, the environment was constrained for the rest of the tasks (2, 5, 7, 8, 9, and 10), and the manikin was placed intuitively.

A significant difference existed for Tasks 3 and 6 for both the RULA score and safety at work score. We found the same safety at work score for 54.5% of the tasks for three simulation tools. The safety at work score for Task 3 was 7 on VR and PMU and higher than 5.4 for DHM, indicating the minor risks at the work situation area. However, the safety at work score was less than 6.5 for the rest of the tasks on three simulation tools—reaching 4 for 24% of tasks (indicating a significant risk for the operators).

TABLE 4: Musculoskeletal Symptoms and Mental Workload (NASA-TLX) for Each Task on the VR and PMU Tools

Ergonomics Parameters	Task	N	VR M (SE)	PMU M (SE)
Musculoskeletal symptoms Lower back	1	6	0 (0)	0 (0)
	2	6	0.5 (0.1)	0.7 (0.1)
	3	5	0.4 (0.1)	0 (0)
	4	5	0.2 (0.1)	0.2 (0.1)
	5	5	0.2 (0.1)	0.2 (0.1)
	6	6	0 (0)	0 (0)
	7	5	0 (0)	0.2 (0.1)
	8	5	0 (0)-----*	1(0)
	9	5	0.2 (0.1)	0.4 (0.1)
	10	6	0 (0)	0.7 (0.1)
	11	5	0.2 (0.1)	0.4 (0.1)
Perceived physical exertion (Borg scale)	1	6	1.8 (0.3)	0.8 (0.2)
	2	6	5.7 (0.6)	4.5 (0.4)
	3	5	2.2 (0.3)	1.1(0.2)
	4	5	2.4 (0.3)	2 (0.3)
	5	5	3 (0.3)	3.4 (0.3)
	6	6	1.8 (0.2)	1.9 (0.3)
	7	5	2.5 (0.3)	2.4 (0.3)
	8	5	3 (0.2)	3.2 (0.4)
	9	5	3.2 (0.3)	1.3 (0.2)
	10	6	3.8 (0.3)	5.2 (0.6)
	11	5	3.4 (0.3)	3 (0.2)
Mental workload (NASA-TLX)	1	6	34.3 (6.1)	18.2 (5.9)
	2	6	61.3 (7.2)	48.8 (6.5)
	3	5	35.3 (6)	27.6 (3.7)
	4	5	37.6 (4.9)	30.1 (2.7)
	5	5	45.1 (7.1)	41.5 (5.3)
	6	6	32.4 (5.2)	28.1 (5.3)
	7	5	41.1 (5.6)	31.7 (6)
	8	5	43 (6.2)	37.8 (6)
	9	5	43 (4.6)	26.8 (3.9)
	10	6	51 (7.3)	56.1 (8.7)
	11	5	42 (5.5)	36.7 (5.3)

Note. NASA-TLX = National Aeronautics and Space Administration—Task Load Index; VR = virtual reality; PMU = physical mock-up.
 Wilcoxon, * $p \leq .05$.

By comparing three simulation tools, it was possible to demonstrate that some maintenance tasks could not be reproduced satisfactorily (Figure 7), particularly for Tasks 3 and 6. These tasks present a significant difference between

DHM, VR, and PMU for the indicators of safety at work and the RULA score. Both Tasks 3 and 6 aimed to manipulate an electrical generator and a hydraulic drain. For Task 6, the manipulation of the drain collector is performed from

TABLE 5: Comparison of the Three Simulation Tools Based on RULA Scores and Safety at Work Indicators for Each Task

Ergonomics Parameters	Task	N	Digital Human Modeling M (SE)	Virtual Reality M (SE)	Physical Mock-Up M (SE)
RULA	1*	6	3.33 (0.3)	2.5 (0.3)	2.7 (0.3)
	2	6	6.83 (0.2)	7	7
	3**	5	5.83 (1.2)	7	7
	4*	5	6.33 (0.3)	7	7
	5	5	6.83 (0.2)	7	7
	6**	6	5.5 (0.7)	4.17 (0.2)	4.16 (0.1)
	7	5	7	3.9 (0.2)	4
	8	5	7	7	7
	9	5	6 (0.4)	4	4
	10	6	6.17 (1.3)	7	7
	11*	5	6.67 (0.3)	7	7
Safety at work indicator	1	6	4	4	4
	2*	6	5.7 (0.3)	6.5 (0.3)	6.5 (0.3)
	3***	5	5.4 (0.3)	7	7
	4	5	4.8 (0.2)	5	5
	5**	5	5.6 (0.3)	6.4 (1.8)	4.4 (1.8)
	6***	6	4.83 (0.2)	4	4
	7**	5	6	4.4 (0.8)	4.4 (0.8)
	8	5	5	4.4 (0.8)	4.4 (0.8)
	9	5	6	6	6
	10	6	4	4	4
	11	5	6	6	6

Note. RULA = rapid upper limb assessment.
Friedman test: * $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

the platform, without real environmental constraints (helicopter structure, wire, etc.). Poor accessibility and the resulting awkward posture were the common risk factors for Tasks 3 and 6. The maintenance operators had to work in a kneeling posture and pass their upper body through many electrical wires, hydraulic pipes, and mechanical systems.

Moreover, 11 maintenance tasks were performed in the confined space—without the possibility of prolonged displacement and moving around the helicopter—in the work area (limiting the freedom of motion). This condition reduced the variability of postures and the operational leeway of the maintenance operators.

However, the maintainability stakeholders could easily make the best choice for placing DHM in the work environment.

DISCUSSION

This study aims to evaluate the difference in estimating the common HFE indicators between three main simulation tools—DHM and VR in the digital category and PMU in the physical category—through a case study in the helicopter industry. We found that the estimation difference for the majority of HFE indicators was not significant between VR and PMU, except for time execution. However, DHM, VR, and PMU estimated different scores for



Figure 6. The operator performing a maintenance task with similar ergonomic characteristics for digital human modeling, the virtual reality platform, and the physical mock-up.

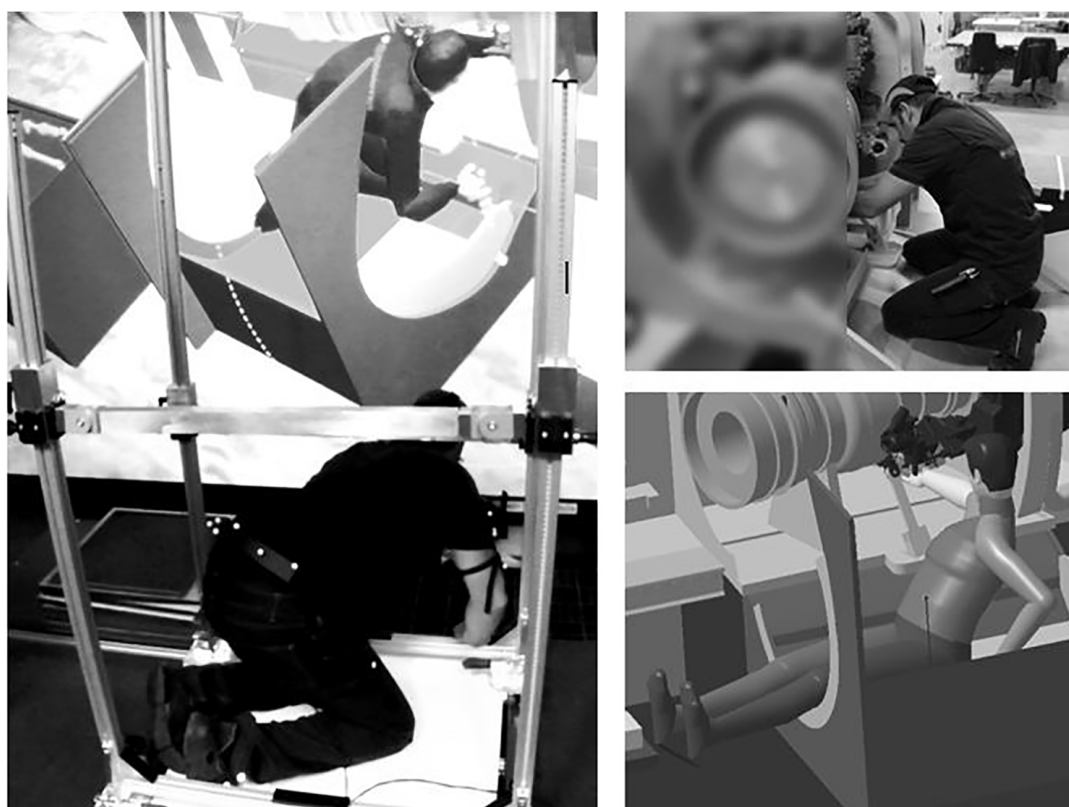


Figure 7. A task with different postures on digital human modeling, virtual reality, and physical mock-up for the same operator.

posture assessment (RULA) and safety indicators for several tasks.

The duration of task execution between the theoretical time estimated by the MTM method and the task execution on VR and PMU was different and the tasks performed on both simulation tools required an execution time that was

higher than the theoretical time. Only two tasks did not present a significant difference (Tasks 9 and 11) because they were simple tasks (with a few sequences and without significant effort). Theoretical time was estimated correctly. We found that the execution time for more than half of the tasks was higher on the VR platform

than on the PMU tool. One of the reasons may be related to the perception of the environment, which could lead to operators being distracted. In our study, the spatial perception was not realistic (Loomis & Philbeck, 2008) due to the gap between perception of the real environment (that maintenance operators are already familiar with) and perception in the virtual platform. The volume of the room limits the workspace in the VR platform, and new technologies (such as mixed reality) have to emerge to perceive the workspace well (Burns, Salter, Sugden, & Sutherland, 2018).

Moreover, the perception of the environment could be improved by the quality of the initial CAD transferred to the VR platform and by the graphics displayed inside the helmet that provides the optimized technical features such as a more realistic field of view (Bowman & McMahan, 2007). Some maintenance tasks (Tasks 1, 3, 6, and 7) required a large workspace in the VR room to ensure the same movement in the workspace volume perceived on the digital immersion. As the physical space of the VR platform limited the movement/displacement of the operators, they had to think and choose a strategy to reach the final destination in the digital immersion and to compensate for this difference.

On the contrary, several tasks required a higher execution time on PMU due to the limitation of physical contacts and the lack of representation of all the physical elements on the VR platform. For example, the torquing bolt was a frequent task in maintenance, but, we could not reproduce this forceful task in VR platforms. Lawson, Salanitri, and Waterfield (2016) have already detailed these specific requirements of VR. The development and integration of physical parts into the VR platform may improve the efficiency of simulation and reduce the gap between real and digital simulation. Therefore, we inserted into the VR platform the physical parts (hatch, table, or wall) to represent the primary physical contacts and mobile parts with a tracker (real torque wrench and an alternator) to reproduce force, similar to previous studies (Menezes, Gouveia, & Patrão, 2018). Several studies proposed the haptic system to improve the quality of VR platform in aeronautic (Savall, Borro, Gil, & Matey, 2002), medical (Wang

et al., 2017), and automotive industries (Langley et al., 2016). However, this technology is costly, which justifies exploiting the current potential of tracking technology (Meier & Holzer, 2015; Riley, 2016). Using real parts with trackers is cheaper than the haptic system and provides a more realistic HFE assessment.

Furthermore, although the participants in our study were trained and immersed in the VR platform 1 week before the experiment, they were unsettled at the beginning of the experiment, needed a few minutes to find their bearings, and adapted to a virtual environment by considering their knowledge of the real world. Motion sickness, especially during a long virtual simulation, also appeared to be a considerable issue (Chen et al., 2017). A long break between the tasks was required in the VR platform to enable the operator to continue the experiment under safe conditions. Therefore, the sequence may not be sufficiently realistic because, in reality, an operator does not take a break between each task.

Our findings suggest that managing the perception of the environment and physical contact were primary influences on the work sequences and the organizational aspect. Indeed, the realism of contacts and forces with real parts and maintenance tools tracked on the VR platform superimposed virtual and real contact, reproducing the force and posture perception (Seth, Vance, & Oliver, 2011). Therefore, the assessment of the other HFE indicators (posture, force, safety parameters, mental workload, and MSD symptoms) was not significantly different between VR and PMU in this study. Pontonnier et al. (2014) reported a difference between VR and PMU to assess HFE indicators when the physical contact and force are not present on VR.

The study of the reach envelope between DHM, VR, and PMU did not present any significant difference as it systematically gave an optimal score of 100% for 11 tasks and six operators. Five tasks showed a significant difference for the RULA score and safety indicators between DHM compared with VR and PMU. These tasks concerned specific work situations where the operators must typically be in contact with the environment; however, when these situations were developed on DHM, the engineers did not have sufficient technical information

about all the potential contacts between the various parts of an architecture. For example, the engineer put in contact the manikin on DHM with the firewall in Task 4, but this contact is forbidden because the firewall could be broken. Therefore, the posture for Task 4 is more comfortable in DHM than in VR and PMU, which resulted in the lowest posture score on DHM. The lack of communication on technical information between different design office departments and maintainability engineers performing the analysis may be the reason for the differences observed for safety indicators between the tasks in DHM and VR/PMU. For example, we observed the same behavior, posture, and contact with the environment in all three simulation tools (Figure 6) for Task 2 (disassembly/assembly of an alternator weighing 18 kg). The main reason for this similarity, especially on the DHM, might be related to the confined space, in which the maintainability stakeholders had only one choice to place the manikin. However, there were two safety risks that the DHM analysis did not report—cutting the edge of the firewall and slipping due to oil leakage on the floor (explaining the lower safety score on DHM).

The DHM lacked detail in the digital environment, and it may mislead the maintainability stakeholder when performing the simulation. This difficulty might be due to using DHM in the very preliminary stage of the design process, where the definition of the work situation is not optimal, and the information transmitted to the maintainability engineer will change every day because of the iterative process (Pistikopoulos, Vassiliadis, & Papageorgiou, 2000). The maintainability engineer performs the HFE analysis when the architectural structure of the product is not yet frozen on one or several complex tasks in DHM, independently of the other tasks in a work area, meaning that the study excludes other maintenance tasks in this area (Bernard, Zare, Sagot, & Paquin, 2018; De Sa & Zachmann, 1999; Regazzoni & Rizzi, 2014). The architectural structure would probably change throughout the design process, while DHM would not be repeated or would only be repeated for a specific task due to various constraints such as time limitation and the limitations of other departments. By changing this paradigm and studying

a zone by DHM instead of the specific complex tasks, we can include several tasks very early in an area, and the efficiency of modification on the new architecture would improve. This paradigm of performing the HFE analysis on a specific task is the same for VR and PMU. This approach may be effective with VR and PMU because these simulation tools are used later in the design process, when the technical information is more stable and complete. However, we propose changing this paradigm for the DHM study and performing the HFE analysis according to the work area. The HFE indicators may be assessed in DHM according to the work area by selecting and simulating various maintenance tasks (the most complex one that affects the operator's activity). This approach may make it easier to gain an overview of the central issues in the interaction between the digital manikins and the environment.

One of the limitations of this study is the small sample size of maintenance operators, which was due to the industrial constraints. Furthermore, one of the participants could not finish all of the experiments, and we had to exclude him from our study. It may be useful to test these simulation tools and other new technologies (augmented reality and mixed reality) with a large population and in several work areas. The results of this experiment should be generalized only with caution, as working on the other parts of the helicopter (such as the tail rotor, inside the cabin, or the cockpit) may provide different results for each simulation tool. The operator's perception may be different when completing the maintenance task in a real situation (typically in the cabin within a confined space) compared with the situation in our experiment where the tasks were performed at heights of three meters on the upper deck (engine).

Our findings open up a debate on the application of the simulation tools that significantly influences the integration of HFE into the design process, not only the maintainability department but also all departments that are connected by a single project. Therefore, we propose developing a tool in a further study explicitly aimed at those who are not experts in HFE to use simulation tools (DMU and PMU) in an efficient manner during design development.

CONCLUSION

Through this industrial experiment on the maintenance activity of a helicopter manufacturer, we confirmed potential interest related to using the digital simulation tool through the VR platform by inserting physical parts to simulate real contacts and forces with the participation of the real operators. We found similar results for biomechanical indicators (such as posture and force) and mental workload in VR and PMU. To improve the assessment of the duration of time execution, we propose improving operator training in VR and better anticipating the physical side added in the VR room. In addition, the DHM produces a significant difference for various maintenance tasks that highlights the need for developing a new paradigm: during a maintainability analysis, do not perform an HFE analysis by individual task, but instead by area, including various maintenance tasks.

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KEY POINTS

- VR simulation must be better anticipated to enhance the integration of real physical parts in the VR room;
- In VR and PMU, we found similar results for biomechanical indicators (such as posture and force) and mental workload;
- Change the paradigm of using DHM: Do not perform an HFE analysis for individual tasks, but instead by area, including various maintenance tasks.
- Simulation tools (physical and digital), common between ergonomists and engineers, can be bet-

ter used to assess ergonomics, especially if the right practices are specified and made known to all actors in the design office.

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PRÉSENTATION DES AUTEURS

Thomas Buhler est maître de conférences HDR en aménagement et urbanisme à l'Université de Franche-Comté (UMR6049 Théma). Ses recherches portent notamment sur les modalités d'action et les stratégies d'acteurs en urbanisme. Dans ce cadre, il mobilise de nombreuses méthodes complémentaires, avec une préférence pour les méthodes mixtes, permettant d'articuler données compréhensives à des données plus systématiques et objectivées.

Virginie Lethier est maître de conférences en Sciences du langage à l'Université de Franche-Comté (ELLIADD, EA4661). Ses recherches s'inscrivent en analyse du discours et prennent pour objet privilégié le discours institutionnel à partir de différents cas d'étude et de genres du discours variés. Spécialiste des méthodes d'analyse du discours outillée, Virginie Lethier interroge dans ses travaux les apports et les limites des méthodes textométriques pour l'analyse de corpus textuels. Elle participe activement à la diffusion des méthodes textométriques en participant à différentes activités de formation à l'échelle locale, nationale et internationale.

La publication ci-dessous relate une analyse de discours appliquée à des documents de planification des transports sur une période de 15 ans. Cette étude illustre d'une part, les collaborations fructueuses entre géographes et analystes du discours, et d'autre part, l'articulation forte entre la formation masterale (master Analyse du discours) adossée au laboratoire et ses activités de recherche :

- le vaste corpus sur lequel se fonde cette étude a en effet été constitué grâce à un stage rémunéré confié à l'une de nos étudiantes de M2
- les auteurs de cette contribution sont co-responsables d'une unité de M2 (Méthodologies en analyse de données textuelles) dans le cadre de laquelle, sous la forme de projets tutorés, les étudiant.e.s sont invitées à tester la robustesse de nos résultats par la comparaison de différentes expérimentations méthodologiques.



Analysing urban policy discourses using textometry: An application to French urban transport plans (2000–2015)

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Abstract

This article supplements the array of methods in urban policy discourse analysis by applying textometry to a corpus of planning documents. Textometry is a systematic computer-assisted analysis of textual data. When applied to large corpora, the method can reveal contrasts that cannot readily be detected by non-instrumented human reading. It seems promising therefore to use textometry to analyse urban planning documents which, in France as in other countries, are known for being at first sight pretty indistinguishable from each other. By analysing dozens of documents at a time, this method increases the scale of analysis, enabling us to identify massive transitions in discourse over time or major contrasts among discourses emanating from specific groups of actors. When combined with classical methods (i.e. interviews, qualitative archival research), textometry seems to be effective at identifying new ways of understanding urban policy discourses. To exemplify the potential of such a method, the analysis developed here draws on a corpus of 36 French urban transport plans (plans de déplacements urbains) for the period 2000–2015. Our results display marked contrasts in discourses, mainly as a result of changes over time. Paradoxically, for most cities between 2000 and 2010, the discourses become increasingly abstract in their content while highlighting a proactive attitude and providing specific information on the document implementation process and a precise list of institutional partners.

Keywords

discourse, textometry, transport planning, urban planning, urban transport plans

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摘要

本文通过将文本计量学应用于一系列规划文件，补充了城市政策话语分析方法集。文本计量学是对文本数据的计算机辅助系统分析。当应用于大型语料库时，该方法可以揭示非仪器化人类阅读无法轻易检测到的对比。因此，使用文本计量学来分析城市规划文件似乎是有前景的。在法国，与在其他国家一样，城市规划文件第一眼看上去彼此很难区分。通过一次分析几十个文档，这种方法增加了分析的规模，使我们能够识别话语随着时间的推移而发生的巨大转变，或者来自特定行为者群体的话语之间的主要对比。当与经典方法（即访谈、定性档案研究）相结合时，文本计量学似乎能有效地识别理解城市政策话语的新方法。为了举例说明这种方法的潜力，我们在本文中制定的分析基于2000-2015年期间法国36个城市的交通规划（*plans de déplacements urbains*）。我们的研究结果揭示了话语方面的明显对比，这主要是随着时间的推移而发生变化的结果。矛盾的是，对于2000年至2010年期间的大多数城市来说，这些话语的内容越来越抽象，同时凸显了积极主动的态度，并提供了文件执行过程的具体信息和机构伙伴的准确名单。

关键词

话语、文本计量学、交通规划、城市规划、城市交通规划

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Introduction

Despite the increased use of discourse analysis in the literature on urban policy research, two major shortcomings seem to cast doubt on the scientific character of the methodologies developed (Jacobs, 2006). Much criticism is levelled at the elusive and unsystematic character of these approaches. More precisely, the observed tendency to ‘overgeneralise and infer too much from a particular example’ (Jacobs, 2006: 47) is problematic. A second shortcoming is that most of these approaches tend to over-focus on the language of texts at the expense of social practices. In order to make urban policy discourse analysis more systematic and methodologically explicit, we propose here to explore the potential contributions from textometry, which is a particular form of statistical analysis of textual data. This proposal has to be considered in conjunction with other methods to strengthen the scientific basis of traditional qualitative studies and enhance their capacity to deal with larger data sets.

To exemplify the potential of such a method, the analysis developed here draws on a corpus of 36 French urban transport plans (*plans de déplacements urbains*, or PDUs) for the period 2000–2015. These plans are mandatory documents in France for cities of more than 100,000 inhabitants, and have to be revised every 10 years. The corpus we have analysed encompasses 18 initial and revised versions of such plans. Taking PDUs as source material in this way authorises a potential change in the scale of analysis and provides the opportunity to develop diachronic studies. That being said, these potential changes are dependent on the removal of certain methodological obstacles.

Selecting data and methods for analysing urban policy discourses

‘Classical’ sources and investigative techniques that show their limitations

Many disciplines endeavour to understand the deep-rooted reasons underlying urban policies through qualitative or quantitative

surveys based on data produced and collected in the context of research. These ‘classical’ sources and investigative techniques, such as questionnaires, experiments or interviews with actors, have shown their limits in terms of distanced and systematised analysis of urban policy.

Interviews with actors are the principal method used to access the beliefs and perceptions to which different actors adhere. Yet, this technique has four well-known limitations. The first is the marked tendency by some respondents, most notably elected officials, to resort to a certain form of cant. Accordingly, it is sometimes very difficult to grasp the full complexity of the underlying rationales for implementing a particular project or policy. A second limitation is the phenomenon of ex-post rationalisation, that is, an explanation given for past reasons drawing on elements from the present (Bourdieu, 2000). This distortion of the reasons for the initial action is all the more obvious when actors involved in a project or policy are questioned some decades later. Third, researcher biases may arise due to errors or oversights, be they intentional or unintentional, during interviews (in the same way as with questionnaires or experiments). Lastly, interviews with actors are very time-consuming and thus this method is often reserved for limited data sets.

Some of these problems could be offset a priori by having the same respondents complete the questionnaires. That said, it seems that elected officials are (generally) unwilling to respond to them, despite assurances as to anonymity. Technicians and their views of the policies implemented are therefore over-represented within the public sphere.

Lastly, it is possible to conduct experiments (Tannier et al., 2016) by placing urban policy actors in virtual situations in order to ascertain their opinions and strategies regarding the territory with which they are involved. In the world of city planning,

such experiments are still quite rare. The main shortcoming of this method is that it tends to generalise results, since the experiments simulate a context and a time span for decision making. A further issue is that ‘induced data’ sources of this kind do not allow diachronic analysis.

Archival research does allow diachronic analysis but it has rarely been exploited over long periods of time in urban policy research. This is probably due to the time required for such research, and for organising and analysing the often very voluminous information on a particular subject. These limitations mean that most such research focuses on a particular case study and its results can rarely be generalised (MacCalum and Hopkins, 2011). In urban policy research, the comparative perspective appears to produce quality work. It is, however, conditioned by the development of robust methodologies for analysing large data sets and by the time constraints of research.

Challenges and limitations of urban policy ‘discourse analysis’

Since the late 1990s (Hastings, 1999), numerous research projects in the field of development have claimed to deploy ‘discourse analysis’. The term encompasses very different practices. They fall into two categories (Maingueneau, 2012):

- ‘discourse *studies*’, which shares the common understanding that ‘discourse’ is the simple result of a language practice (conversations, interviews) produced in a particular social and political context. Discourse is considered to be an instrument providing clues that enable researchers to access ‘realities’ lying outside language. These studies, which are in the majority, tend to approach a form of content analysis since they pay little attention to language. They often consider

language to be transparent, and make a distinction between social and linguistic issues. In doing so, they tend to overlook what it is that differentiates the simple output of a communicative interaction from 'discourse'.

– 'discourse *analysis*' is one of the interpretative disciplines of discourse studies. It specifically considers discourse as the articulation of texts and social practices. Discourse, from this perspective, corresponds neither to the text nor to the situation of communication, but to what links them together through a certain enunciation device (Fairclough, 2003).

The development of research about discourse in urban policies has sometimes been slowed due to numerous critiques – finely expounded by Keith Jacobs (2006). Two of the criticisms that Jacobs pinpoints seem to be closely correlated in that they both involve the scientific rigour of 'discourse studies'. The first pitfall is a lack of explanation about the methodologies used and their theoretical assumptions. The second concerns the traceability of the interpretative path followed by researchers, who allegedly tend to over-generalise the inferences linked to a particular excerpt, the very choice of which may be open to debate. To what extent does the researcher's starting hypothesis contribute to them focusing their attention on one excerpt rather than another? This criticism concerns the risk of circularity associated with a hypothetical-deductive approach.

Faced with these two first limitations, we propose here a method that could potentially enhance urban policy discourse analysis: the use of textometry applied to urban planning documents. At the crossroads of language sciences, statistics and computing, textometry is not a 'new' method since it is based on lexicometry's heritage (Lebart and Salem, 1994), which arose in France in the 1970s.

Textometry relies on a quantitative data analysis, which mediates the researcher's relationship with the text: it allows extensive and precise counts of the vocabulary used in a large collection of textual data, the consultation of which suspends interpretative activity pending observation and description phases. Beyond that, textometry allows a wide range of sophisticated statistical computations aiming at exploring semantics (co-occurrence networks, contextual attraction of terms) or at comparing and contrasting the characteristics of several texts (over- and under-use of terms in the various divisions of the corpus, factorial analyses). Textometry is efficient at identifying similarities and variations between texts or groups of texts, while maintaining a contrasting approach (Comby, 2015). When applied to voluminous corpora, this method can reveal contrasts in discourses that could not readily be detected by non-instrumented human reading or be predicted on the basis of common knowledge. Significantly, textometry differs from other statistical approaches to textual data in that it attaches importance to the text as an empirical and theoretical object. In that respect, textometry tools, such as the open and free-of-charge TXM tool¹ (Heiden, 2010), are distinguished by functionalities (concordancer) and an ergonomic design that allows users, with just one click, to return to the text in order to observe the actual occurrences in context, and thereafter to construct qualitative interpretations. Within the limits of this article, we shall focus on the heuristic value of textometry and its capacity to support an inductive approach to a large amount of textual data.

Urban planning documents as institutional discourse

In combination with a corpus of planning documents, textometry enables a change of scale (wider scale of data, diachronic

perspective) compared with traditional investigative techniques. Textometry also provides a methodology that serves a discourse analysis perspective in an appropriate way. What we understand by 'discourse' is a specific enunciative device that has to be described and interpreted from several standpoints of entanglement between a text and social practices (i.e. several urban and political contexts).

As explained by Fairclough (2003), no text can be produced without a social practice and each social practice is distinguished by its own authorised language forms (type of texts, language registers, etc.). In the French tradition of discourse analysis, the notion of a 'discourse type' is a decisive conceptual tool for thinking about this link between a verbal production of a particular practice and its particular communication devices (*dispositif de communication*). From that perspective, urban planning documents have to be considered as utterances of *institutional discourse* (as against political discourse, media discourse, etc.). This term refers to a discourse with a strong active and performative dimension produced by an institution, emanating from a collective entity presented as indivisible while being the product of a negotiation between various points of view. Therefore, institutional discourse is guided by a dual principle of stabilisation of statements and erasure of conflict (Krieg-Planque and Oger, 2010). The latest research highlights the fact that institutional discourse is characterised by linguistic regularities: a marked appetite for stereotypical writings (not to say 'clichés'), phraseological elements and performative utterances (Krieg-Planque, 2012).

Hence, it is not surprising that, as with most operational spheres or in research on urban public action, urban planning documents in general and PDUs in particular should be described as 'wishy-washy', 'polished' and 'non-conflictual' (Offner,

2006: 15). The apparent 'uniformity' of these planning documents is specific to institutional discourse. From a methodological point of view, the questions arising around the standardisation of their contents correspond particularly well to the opportunities textometry offers. Planning documents have been the subject of processes of 'smoothing' (Oger and Ollivier-Yaniv, 2006), and are known to be prolix and at first sight somewhat similar in terms of content. Statistics, the science of gaps par excellence, makes it possible to direct researchers to both the common trends in the documents and the (more or less discrete) variations within them.

Data and method

PDU: Content and governance

The method we discuss here focuses exclusively on the plan itself as research material. This excludes de facto newspaper articles, reports of proceedings, public statements and press releases that go along with the whole implementation process of the plan. In that respect, it seems necessary to present a brief description of a PDU, its content and the governance structures affecting the implementation of these documents.

In a nutshell, PDUs are mandatory documents in France for cities of more than 100,000 inhabitants. They are equivalent to other urban transport plans in Europe, as they concern planning transport for people and goods on the scale of the conurbation. They deal with the infrastructures and services to be put in place, changes in transport modes, urban logistics and access for the disabled. The organisation implementing the PDU may be either the public transport authority or the local authority. This project owner is often associated with a consulting office specialised in urban or transport planning. Apart from these two main structures, other actors are involved during the PDU

consultation process: different authorities (*Régions, Départements*, neighbouring local authorities), chambers of commerce and public transport users' associations. The whole process generally lasts three to four years and finishes with the final approval (or disapproval) of the Prefect, that is, the local representative of central government. This final procedure is to check that the PDU complies with the legislation in force. A revision of the document is required every 10 years at least.

For a better understanding of the current governance structure surrounding PDUs, it seems necessary to clarify its origins. In France, the idea of transport planning on the scale of the conurbation emerged with the 1982 LOTI Act, in a broader context of government decentralisation. This first wave of incentives suggested the implementation of a PDU for all interested cities, without any real statutory constraint. Only a few local authorities showed interest, and none successfully completed the implementation process. Indeed, successive political changeovers in central government in the 1980s made this document progressively obsolete.

The vast majority of French cities devised and put in place their first PDU in the early 2000s. Most of these early plans correspond to the 1996 LAURE Act and more specifically to the requirement to produce a PDU 'within three years', bolstered by the stipulation (in the 2000 SRU Act) for cities to produce a PDU in order to secure financial support from central government for their 'dedicated public transport lane' projects. This legal obligation appeared in order to speed up the implementation of the plans. Several local authorities failed to meet the original deadlines and proved reluctant to implement their first PDU. Some local actors saw PDUs as yet one more document in the long series of requirements imposed by central government (Offner, 2006).

As a result of this evolving legal context, two main waves of approvals of mandatory PDUs emerged. The first was in 2000–2005, followed by a second wave of revised documents in 2010–2015 in line with the statutory limit of 10 years for the revised version. The corpus we have analysed follows these two main waves.

Since the general reorganisation of the French national planning system through the 2000 SRU Act, the PDU has played an important role. Local urban planning schemes (PLUs – *Plans locaux d'urbanisme*), defining land-use at the municipality level, have to be consistent with their respective PDU. And the PDU in turn has to be compatible with broader supra-local orientation documents.

That being said, in terms of content, the PDU cannot be considered to be a strong commitment: no legal consequences ensue if the objectives are not attained. In order to enhance the responsibility of the local authorities towards their own prior commitments, the 2010 *ENE* Act added the requirement of an environmental evaluation of the previous PDU for every revised plan.

Representative character of the sample

The objective of analysing PDU discourses on a larger scale (wider scale of data, diachronic perspective) with textometry requires a representative sample of the 'parent population' of all cities obligated to put in place and revise a transport plan in the period 2000–2015. The 36 urban transport plans consist of two issues for 18 French cities (Table 1).

As a quick analysis of the metadata, the sample is representative whether we consider the population present within the 'urban transport perimeter', the type of organisation producing the document or the political affiliation of the political majority when

Table 1. Descriptive statistics of the sample analysed ($n = 18$) and of the parent sample of French cities connected to the transport plans ($n = 66$).

Variables	Categories	Conurbations in the corpus ($n = 18$)		All conurbations in France required to produce and update an urban transport plan ($n = 66$)	
		$n =$	Frequency	$n =$	Frequency
Population within the urban transport perimeter in 2012	(1) $> 1,000,000$	2	11%	4	6%
	(2) 500,000–1,000,000	2	11%	5	8%
	(3) 250,000–500,000	5	28%	16	24%
	(4) 100,000–250,000	8	44%	36	55%
	(5) 50,000–100,000; and	1	6%	5 (4 + 1)	8%
	(6) 25,000–50,000				
Type of organisation producing the urban transport plan	Council	12	67%	52	79%
	Public transport authority	6	33%	14	21%
	Left (PS, PCF, Verts, MRC, PRG and divers gauche)	9	50%	30	45%
	Right (RPR, UDF, MPF and divers droite)	9	50%	36	55%
Affiliation of political majority in the executive of the organisation producing the plan in the 2000s	Left (PS, PCF, Verts, PRG and divers gauche)	13	72%	46	70%
	Right (UMP, UDI, Nouveau Centre and divers droite)	5	28%	20	30%

Notes: The results for the 2000s for 'all cities' in France correspond to the 2001 municipal election results for the city centres of the 66 urban transport perimeters required to have urban transport plans. The results for the 2010s for 'all cities' in France correspond to the 2008 municipal election results for the same.

approving the two issues of the transport plan. The 18 cities analysed provide a good representation of the diversity of cases to be found for all 66 French areas involved in the urban transport plans. Of course, some minor deviations are observed, with in particular a slight over-representation of cases where public transport authorities are the project owners of the document (33% versus 21% for all cities). In terms of city size, the sample of transport plans contains slightly more 'extreme' cases (very large and very small cities). The class of cities with 100,000–250,000 inhabitants is therefore slightly under-represented (44% in our sample versus 55% in reality). Despite these slight deviations, we can assert that based on these criteria, the sample proposed is representative of the diversity of cases found nationwide.

A voluminous and homogeneous corpus

Since it brings together texts produced under similar conditions, our corpus meets the homogeneity criterion required by any computer-assisted discourse analysis. All the documents studied belong to the same 'discourse genre' (Maingueneau, 2003), that is, a socio-historically constrained communication device that structures texts in specific ways (thematics, structure, style, etc.). For example, most of the 36 documents we study have a generic structure of the type 'diagnosis/project/action'. Each part of the document has the characteristic of being highly structured and hierarchically arranged through a system of titles and headings. These documents are all written in a standard register and the marks of the writer's presence are erased. All these common features are noteworthy as no specific size or form is required by law (unlike for other French planning documents).

This corpus is also large enough to justify the use of a statistical analysis methodology: it represents a substantial set of 1,673,335 words, to which each PDU contributes. Since there are no legal requirements as to the format of the PDU, the number of pages varies greatly from one document to another, ranging from 64 pages (Tours, 2003) to 285 (Aix, 2015). Some 55% of the PDUs in our corpus are between 100 and 200 pages long. The number of words also varies significantly from one document to another. Although most texts contain between 20,000 and 60,000 words, we observe a considerable increase in the number of words over time. Documents produced in the 2000s average half the length of documents produced in the 2010s (30,390 words on average for the 2000s versus 61,461 for the 2010s).

Our approach focuses on textual data alone and eliminates all of the illustrative components such as maps, drawings and photographs, despite their obvious value (Dühr, 2006). The use of these illustrative elements, in particular photographs, would be worth investigating. For example, the almost systematic use of photographs of bicycles in PDUs seems to be a tool for building a positive discursive image of the city, featuring the integration of valued social norms. While portraying 'social desirability', the means of transport highlighted in the photographs do not correspond to those that predominate in the plans.

A systematic semiological analysis of illustrative elements of plans could provide additional insights into our method and could shed a complementary light on the potential existence of compensation effects between illustrations and texts. Apart from the over-representation of certain transport modes in visual elements, we identified a duplication of the textual elements by different illustrative elements in the PDU corpus studied here.

Results

FCA as an exploratory class of analysis

Within the limits of this article, we will focus on one single class of analysis: a factorial correspondence analysis (FCA) performed on the vocabulary of the corpus presented earlier. Inspired by C Spearman (Martin, 1997), FCA was developed by the French mathematician JP Benzécri in the early 1970s on the basis of mathematical principles that are well detailed in an abundant reference literature (Cibois, 2014; Murtagh, 2005). This tool, which is closely associated with the '*école française d'analyse des données*' (Benzécri, 1984), has expanded beyond national boundaries (Greenacre and Blasius, 1994) and is nowadays currently used to design synthetic visualisation of the vocabulary distribution as a function of selected variables.

It is important to understand that this methodology has an exploratory consistency and is usually used for its heuristic potential: its main goal is not to 'prove' but to suggest pathways for analysis, by giving a preliminary view of the associations (and contrasts) between the lexical items and certain variables.

In order to identify the similarities (and dissimilarities) between the PDUs, and consequently to examine the factors underlying them, we constructed a contingency table with 36 columns (one for each PDU) and 268 rows corresponding to verbs, common nouns and adjectives occurring at least 500 times within the corpus. At the intersection of a row and a column, the number of occurrences of the unit under consideration for a certain PDU was recorded.

By using these grammatical types and a minimum frequency criterion of 500 occurrences, we were able to filter out terms relating to local specificities (e.g. proper nouns for places or elected officials) so as to

concentrate on the common base of the discourse and to enable comparisons.

We chose not to limit ourselves to nouns. Extending our quantitative statements to the verbs used enables us to take into account enunciative devices (or 'ways of saying things') through which the institution portrays itself. Moreover, since the institutional discourse (Krieg-Planque and Oger, 2010) tends to contain a plethora of phraseological units, the analysis of adjectives helps to refine the profile of general common nouns. A general term such as 'transport' is an invariant in the text: it is only through the use of an adjective (e.g. public, sustainable) that a specialised meaning is created.

Technically, our analysis is based on lemmas, that is, conventional lexical forms which group all the conjugated forms (e.g. 'is', 'are') under the same entity (e.g. 'be') and erase the plural and gender marks (e.g. 'car' rather than 'cars'). In other words, in the case of verbs, lemmas are obtained by reducing all conjugated forms to the infinitive. Similarly, nouns and adjectives are reduced to their masculine singular forms.² We thus categorised each of the 1.67 million graphic forms of the corpus by referring them to their corresponding lemma, and thus made our data more readable.

This is where the FCA comes into play: it extracts the information contained in this complex table and transforms it into a simplified reading of the main contrasts structuring the vocabulary. Mathematically, the construction of such an FCA comes down to calculating distances (of the Chi-square type) between sub-corpora (in our case, between different documents) by taking into account the (relatively) commonly or rarely used lemmas. These distances are then broken down over an ordered series of factorial axes.

After these calculations, the resulting FCA (Figure 1) is synthetic and easy to read: the more 'central' a lemma is (i.e. when

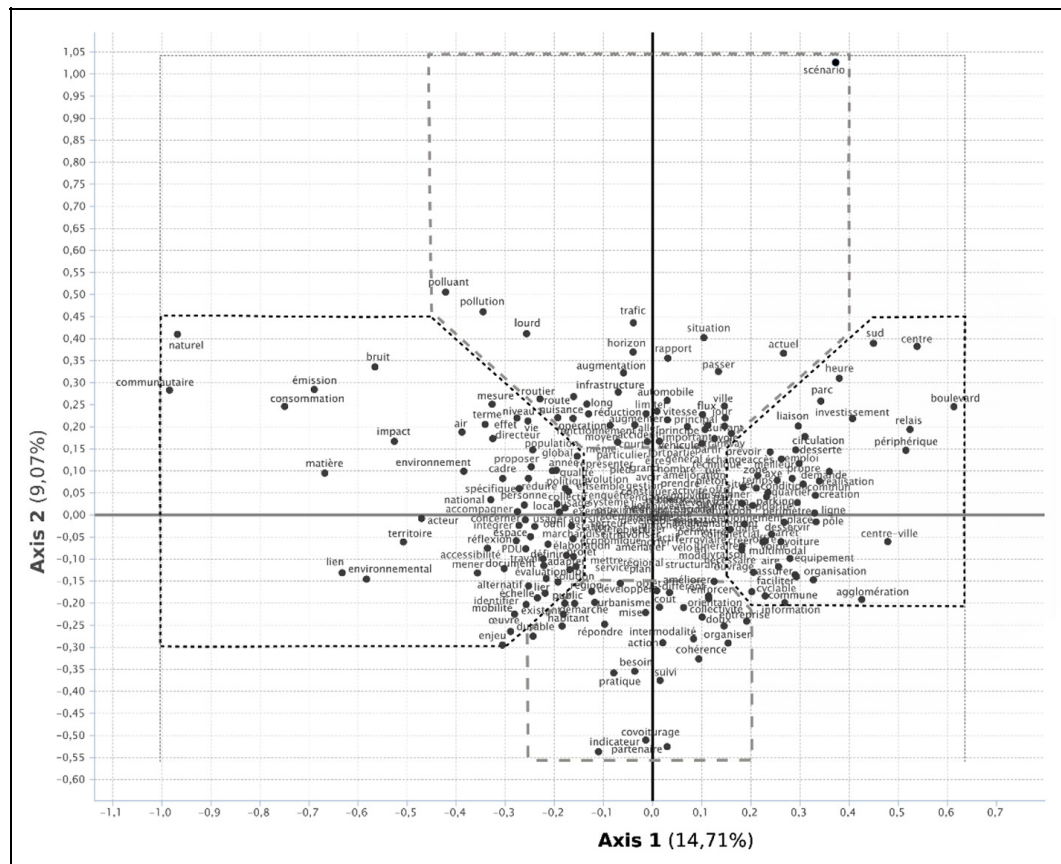


Figure 1. FCA of the distribution of the most frequent lemmas within the corpus.

its factorial coordinates are close to 0;0), the more common it is. In other words, these central items have a statistically insignificant profile. On the contrary, a very specific lemma will be plotted towards the edges of the FCA. Two lemmas that have similar factorial coordinates tend to have a comparable distribution within the 36 PDUs (e.g. the items *link* ‘lien’³ and *environmental* ‘environnemental’, on the left side of Figure 1).

We systematically analysed the textual passages in which the outlying (specific) lemmas occur, by using TXM concordancer: with one click, this tool allows a synoptic reading of textual contexts in order to analyse the meaning of a given term. This ‘back to text’ step is essential to avoid over-interpretations, and makes it possible to overcome the pitfalls of purely

quantitative approaches. For example, we analysed the different meanings of the term *accessibility* ‘accessibilité’. Going back to the text, the classification of the types of context reveals that out of 1645 occurrences of the lemma, only 248 occurrences (15%) are associated with the idea of geographical accessibility (to different places by different modes). The vast majority of uses of this term refer to the issue of disability and particularly to the access for the disabled to transport networks or public buildings.

Discursive oppositions following two major sets of contrasts

Figure 1 shows the result of this factorial correspondence analysis.⁴ Its two principal

factorial axes have 23.78% inertia. This means that nearly a quarter of the general distribution of the 268 lemmas can be explained by the combination of these two axes. Given the very large number of documents analysed in a disaggregated manner, and the large number of lemmas considered, this percentage of inertia is sufficient to understand the main contrasts that structure this corpus.

A fine analysis is then required to interpret the meanings of the axes and whether they bring out contrasting registers attesting to the existence of an opposition or a change over time. After a consistent time spent between the analysis of the synthetic FCA and the analysis of the different contexts of use of the lexical units, we can assert that this PDU corpus is structured around several sets of contrasts statistically corresponding to the two main axes.

In order to identify the lemmas whose distributions structure the two main axes, we focus exclusively on the lemmas that contribute markedly to them (Cibois, 2014) on the basis of ($|X|$ or $|Y| > 0.15$). Then, each lemma is associated with the axis to which it contributes most. These two criteria make it possible to divide the FCA into four specific sectors on which the analysis will focus (see Figure 1).

Axis 1 is statistically the one that most obviously structures the contrasts in discourse within the corpus (14.71% inertia). First of all, it reflects a split between a very concrete and precise vocabulary concerning transport issues, concentrated on the right side of the graph, and a conceptual vocabulary mainly concerning environmental issues, which is found on the left side of the graph.

Thus, the right side of axis 1 concentrates very specific terms that refer to different real-world objects, such as *park-and-ride facilities* ('parc', 'relais'), *ring road* ('boulevard', 'périphérique'), *exchange centre* ('pôle

[d'échange]'), *lane* ('ligne', 'liaison'), *parking* ('stationnement'), *roads* ('voirie'), as well as precise locations (*downtown* 'centre-ville'; *perimeter* 'périmètre'; *district* 'quartier'; *centre* 'centre'; *south* 'sud') and specific time units (*day* 'jour'; *hour* 'heure'). We finally observe in this area lexical forms linked to the materialisation process of concrete services and objects (*creation* 'création'; *construction* 'réalisation') and their organisation ('organisation'; *to serve* 'desservir'; *to provide a service* 'assurer').

On the contrary, the left side of the plan features terms related to environmental issues (*natural* 'naturel'; *impact* 'impact'; *environment* 'environnement'; *emission* 'émission'; *noise* 'bruit'; *air pollution* 'pollution' [de l']'air'; *effects* 'effets') and terms concerning the question of accessibility for the disabled (*accessibility* 'accessibilité'). On this left side, verbs typically suggest a proactive posture (*to lead* 'mener'; *to integrate* 'intégrer'; *to propose* 'proposer'; *to reduce* 'réduire'; *to adapt* 'adapter'; *to define* 'définir'). Nearby, we observe forms that reflect the process of implementation of a PDU itself ('PDU'; 'document'; *national framework* 'cadre' 'national'; *measure* 'mesure'; *implementation* '[mise en] œuvre'; evaluation 'évaluation'), and the actors involved in it (*intercommunal actors* 'acteur' 'communautaire'; *users* 'usager'). Finally, this part of the graph suggests a marked abstraction that can be identified from conceptual terms such as *territory* ('territoire') and *mobility* ('mobilité') as well as generic terms such as *public space* ('espace' 'public'), *challenge* ('enjeu'), *scale* ('échelle') and *reflection* ('réflexion').

Axis 2 (9.07% inertia) marks a contrast between several groups of lemmas, some of which are semantically linked with the contrasts noted for axis 1. The first type (top of the FCA) essentially shows terms describing recent changes (*increase* 'augmentation'; *increasing* 'augmenter'; *evolve* 'passer' [de ... à]; *compared with* [par] 'rapport' [à])

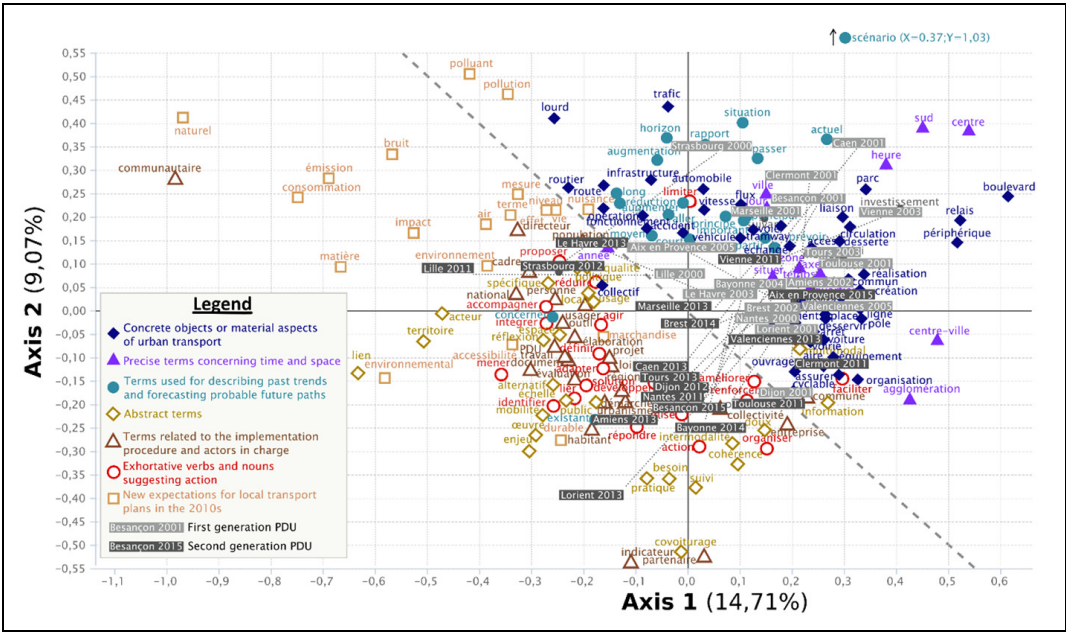


Figure 2. Main discursive contrasts within the PDU corpus (2000–2015).

and terms forecasting probable future paths (‘scenario’; by ‘[à l’]horizon’) concerning classical transport indicators (*traffic* ‘trafic’; *flows* ‘flux’; speed ‘vitesse’). These indicators concern mostly cars (‘automobile’) and more generally road transport (‘routier’; *trucks* [poids] lourds’), and their negative externalities (‘pollution’; *pollutant* ‘polluant’; *nuisance* ‘nuisance’). To summarise, this upper part of axis 2 encapsulates the vocabulary of diagnosis of a *current situation* (‘situation’; ‘actuel’).

By contrast, the verbs and nouns at the bottom of the plan tend to justify taking initiatives in order to enable changes (*to reinforce* ‘renforcer’; *to improve* ‘améliorer’; *to respond to* ‘répondre’ [à]; *action* ‘action’).

As for the left side of axis 1, this lower part of the FCA also groups terms linked with either abstract or conceptual aspects (*practices* ‘pratique’; *consistency* ‘cohérence’; *intermodality* ‘intermodalité’; *soft [modes of transport]* [modes] ‘doux’), connected with the markers of the PDU as a process (*monitoring* ‘suivi’; *indicator* ‘indicateur’; *urban*

planning process ‘démarche’ [d’]‘urbanisme’ etc.), involving a plurality of actors (*partners* ‘partenaires’; *inhabitants* ‘habitants’; *local authority* ‘collectivité’; *firm* ‘entreprise’).

Combining the two axes to understand discourse transitions

To enhance the readability of the FCA, we have categorised the different lemmas which contribute strongly to the axes ($|X|$ or $|Y| > 0.15$), following the categories previously identified through the analysis by axis. Figure 2 makes it clear that the discursive contrasts presented above very strongly overlap with the distinction between the first and second generations of documents.

In other words, the discourses from 2000 to 2005 correspond statistically to the upper and right parts of the factorial plane, whereas the second-generation discourses (2010–2015) correspond statistically more to the lemmas of the left and lower parts of the FCA. We can therefore speak of a

predominant discursive trajectory on the scale of our corpus. Out of 18 agglomerations, only one (Aix-en-Provence) does not geometrically follow this trajectory.

Traces of this diachronic trajectory can thus be broken down into four trends which interact with each other. First of all, an increasing use of abstract vocabulary can be noticed (Figure 2, see empty diamonds). This evolution is indicative of the shift from a technical document with a descriptive consistency centred on precise and concrete real-world objects (see filled diamonds) and precise terms concerning time and space (see filled triangles), to a fully institutional document with a programmatic consistency, focused on issues of higher complexity. It should be noted that from 2010 onwards, the documents reflect a greater drafting effort, incorporating a higher proportion of complete sentences, to the detriment of verbless sentences and the list format characteristic of earlier 'technical' versions.

The second trend is an increased use of terms symptomatic of environmental concerns, logistics and accessibility issues for people with disabilities (Figure 2, see empty squares). Needless to say that the higher frequency of use of these terms may be regarded as strongly driven by the new legal expectations of urban transport in the 2000s.

The third trend observed concerns a change in the posture displayed by the producer of the text: in the second-generation texts, the verbs support a portrayal of the producer of the document as a proactive agent. By dint of exhortative verbs (Figure 2, see empty circles), this discourse justifies the implementation of actions as a positive way to improve the current situation.

The fourth (and last) trend is based on the actors mentioned in the PDU. In the first generation of texts, few actors are mentioned. In the second generation, the actors involved in the implementation procedure are mentioned far more frequently.

To sum up, two models can be distinguished. The first model, which can be characterised as 'concrete, precise and descriptive', tends to cluster urban transport plans drafted in response to a statutory duty in a rather descriptive register, concretely listing and precisely stating the arrangements to be put in place. Very few actors or items of procedure are mentioned in this first model. The focus is on the technical realisations considered as a reaction to a rather unpleasant current situation. This is more the case of the first generation of transport plans dating from the years 2000–2005. It is worth recalling here the context surrounding the creation of this document: at this time the French central government was having great difficulty in getting local authorities to implement their first PDU. By way of illustration, here is one (translated) example of the 'concrete, precise and descriptive' model characterising plans of the years 2000–2005 (words in *italics* are examples of lemmas described in Figure 2):

The *parking organisation* on the inner *boulevards* is one of the major levers to encourage a modal shift from *cars* to *public transport* for working people and students. It concerns the gradual reduction of on-street *parking* spaces, partially offset by the *construction of underground parking* facilities on the *boulevards* (observed from the Pont du Cange to Place Voge, via the Cirque), to 600 spaces from the current 2550. (Amiens, 2002)

A second model of transport plan ('abstract, proactive and cooperative') presents verbs of action that highlight the proactive attitude of the city in tackling issues of urban travel. Although this might seem paradoxical at first sight, such verbs are paired with highly abstract terms. This model affords greater precision about local governance (actors, and implementation phase). By way of illustration, here is one (translated) example of the 'abstract, proactive and

cooperative' characteristics of transport plans of the years 2010–2015:

The main *challenge* of the PCET in transport is to align and articulate a *mobility* strategy around the tramway and the Ginko network to *promote* modal shift through various key actions: *developing* alternative modes to the private car, *modifying* the parking supply, *encouraging* the adoption of new *practices* (cycling, car sharing, carpooling, etc.) and *proposing* efficient and adapted advice to coordinate the whole. (Besançon, 2015)

Discussion

The factor analysis set out in the previous section shows that the discourse in French urban transport plans can be largely explained by its rooting in time. Consequently, the discussion will first centre on this change in discourse over time before focusing on the perspectives offered by such a method.

From the 2000s to the 2010s: A major discourse transition in French urban transport plans

Urban transport plans changed a good deal in the course of the 2000s, making cities showcase their intentions, their partners and their capacity for action; paradoxically, these were expressed in a very imprecise way with respect to the subjects those actions would bear on. What explanation can be given for this transition in transport planning documents towards such a paradox combining willingness to act, clarification about the procedure and partners involved and more abstract content?

Three lines of enquiry seem worth considering. The first is to consider the change in these documents as a sign of the assertion of the power of the city relative to central government, boroughs, organised civil society and inhabitants. Interestingly, two of the

terms that contribute statistically the most to axis 1 are *intercommunal* ('communautaire') and *territory* ('territoire'), which are often combined. The widespread use of 'territoire' is well identified in the literature as marking a determination to build up and assert power (Barreteau et al., 2016). The over-representation of proactive verbs of action may also be understood as part of this process of displaying and legitimising the power of the city.

The second line of enquiry is that *proactiveness–abstraction* pairing can also be used for more 'tactical' purposes. Compared with the risk of a legal appeal against the document, the use of more abstract terms means there is no need to 'show one's cards' until it comes to negotiations about infrastructure funding (with central government or regional councils) or the sharing of space for the various modes of transport (with special interest groups) (Reigner and Hernandez, 2007). It should be noted that one case of PDU refusal by a Prefect occurred in Grenoble in 2006, exactly between the two waves analysed. This decision followed appeals by several associations (cyclists and pedestrians) on very specific and concrete issues, including mode sharing in a new urban tunnel project. This refusal probably set a precedent and led to a more pronounced taste for abstraction in the second generation of PDUs (Reigner and Hernandez, 2007). Moreover, in times of budgetary restrictions and uncertainty for French cities (notably less financial support from central government), a more abstract discourse means that an overall direction can be given with less concern for concrete projects, which there is no guarantee will be financed (and especially jointly financed with other tiers of government) or accepted by the population. The results presented here are in line with recent findings on the role of ambiguity in the political process of public policymaking: abstraction and

ambiguity seem to have the power to cement coalitions between groups of actors (Jegen and Mérand, 2013). The precise listing of the items of procedure and actors involved is another sign of how easy it is to bring a larger coalition together when discourses are more abstract.

Lastly, changes in the actors involved in drafting urban transport plans are a third line of enquiry explaining the shift towards proactive and abstract discourses. From the late 2000s, consultants in public communication have become increasingly involved. This phenomenon completes a broader transformation of the role of mayors and elected officials. For the last three decades in France, these actors have tended to overlook local political management functions (such as cultural associations and sports clubs), concentrating instead on functions of strategic policymaking that are considered 'profitable' in terms of public opinion (Pinson, 2014). This new political situation leads to the systematic involvement of consultants in public communication and consequently to greater use of consensual, pragmatic and abstract forms of speech (Pinson, 2014) at the expense of the technical actors and transport planners.

Perspectives for a textometry-based method in urban policy discourse analysis

These points of discussion highlight the value of what is both a quantitative and qualitative systematic method for studying discourses that accompany and justify urban policies. The predominant discursive trajectory from 'concrete, precise and descriptive' discourses to 'abstract, proactive and cooperative' ones is an original result. Although criticisms were directed at the first generation of PDUs, characterising them as 'wishy-washy' or 'non-conflictual' (Offner, 2006), no other method before has identified this

predominant transition of PDUs to even less concrete and precise content.

Therefore, textometry seems to be effective, in conjunction with classical methods, for identifying continuity, change and other transitions that supposedly cannot be spotted by humans. Even though a 'classical' (i.e. non-instrumented) human reading would have been sufficient to identify the terms related to new legal expectations (environmental evaluation, accessibility for the disabled, etc.), it is very unlikely that stylistic features (such as proactive verbs or conceptual nouns) would have been spotted in such a corpus. And yet these elements are key to understanding discursive transitions.

Textometry applied directly to planning documents can identify predominant trajectories and exceptions (here, Aix-en-Provence), and it makes it possible to build new hypotheses and to test them with other textometry tools (specificity analysis, co-occurrences) or complementary methods (such as explanatory interviews).

This method may well renew urban policy discourse analysis because it can identify contrasts between discourses and track them over time. Analysed as an 'event' in a longer duration 'series' of which it is part, the planning document then becomes the indicator of a balance between opposing discursive forces and, by extension, between multiple actors. Ideologies and strategies can be identified by comparing such situations in time and space:

[...] it seems to be by pushing to its extreme the fine grain of the event, by stretching the resolution-power of historical analysis as far as official price-lists (*les mercuriales*), title deeds, parish registers, harbour archives examined year by year and week by week, that these historians saw – beyond battles, decrees, dynasties or assemblies – the outline of massive phenomena with a range of a hundred or many hundreds of years. (Foucault, 1971: 57, translated by Young, 1981: 68)

Although the method developed here is concentrated for the moment on a decade, it frees urban policy discourse analysis from the specificities of the ‘event’ and analyses it as part of a larger geographical and temporal series. In this way, the textometry approach can reconcile poststructuralist approaches with methods that enquire into discursive materiality, by identifying and situating social actors’ ideologies and strategies through a focus on the text.

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Notes

1. The TXM software can be downloaded from Textométrie (n.d.).
2. As a reminder, adjectives are not invariable in French: an adjective such as ‘big’ (*grand*) has at least four forms (*grand*, *grande*, *grandes*, *grands*) but one lemma (*grand*).
3. From this point on, and for the sake of readability, we will quote the lemmas from the corpus by their English translation (in italics) followed by the original French lemma (in inverted commas).
4. For the sake of readability, the precise location is given for the most specific lemmas only.

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ARTICLE

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The Longest Month: Analyzing COVID-19 Vaccination Opinions Dynamics From Tweets in the Month Following the First Vaccine Announcement

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Contexte

Cet article illustre une fructueuse collaboration internationale d'ELLIADD. En effet, au cours des dix dernières années, le laboratoire ELLIADD a développé des relations sur le plan scientifique avec l'Université d'Études Économiques de Bucarest (UEEB) et, plus particulièrement, avec les laboratoires de la Faculté de Cybernétique, Statistique et Informatique (<https://cercetare.ase.ro/research-centers>).

Les nombreuses actions scientifiques (e.g. contrats postdocs, conférenciers invités, réponses aux appels à projets européens, rédaction et publications de sept articles dans des revues et des conférences) ont eu une contribution importante à l'activité de recherche, aux collaborations internationales et à la visibilité du laboratoire ELLIADD.

Actuellement, notre collaboration porte sur l'application des nouvelles techniques d'Intelligence artificielle dans l'éducation et la communication. Sur ces sujets, en 2019, deux postdocs ont été financés par Pays de Montbéliard Agglomération :

1. « Apprendre à l'ère de l'intelligence artificielle », pour Liviu COTFAS (15.10 – 31.12.2020)
2. « Communiquer à l'ère de l'IA », pour Camelia DELCEA (01.11 – 31.12.2020).

De plus, dans le cadre de l'appel à projets « Professeur invité » 2021, nous avons déposé une demande pour M Liviu COTFAS (à l'époque MCF HDR et depuis février 2022, professeur des universités). Nous avons obtenu un financement pour trois mois dans l'année universitaire 2021/2022. Le projet de recherche porte sur « Encapsulation de connaissances dans un système d'intelligence artificielle pour un dispositif d'apprentissage ».

Une reconnaissance de la réussite de notre collaboration est la publication (le 16 février 2021) d'un article « The Longest Month: Analyzing COVID-19 Vaccination Opinions Dynamics From Tweets in the Month Following the First Vaccine Announcement » dans IEEE Access (Volume:9) (<https://ieeexplore.ieee.org/document/9354776> ou 10.1109/ACCESS.2021.3059821).

Problématique de l'article

L'article utilise une approche multidisciplinaire, combinant des éléments de domaines tels que la linguistique, la psychologie et l'intelligence artificielle afin d'analyser la dynamique des opinions concernant la vaccination COVID-19 dans la période d'un mois suivant la première annonce d'un vaccin.

Le nouveau coronavirus (SARS-CoV-2) a imposé des mesures sans précédent qui ont changé la « normalité » dans laquelle vivaient les gens du monde entier. Avec l'annonce faite le 9 novembre 2020 par Pfizer et BioNTech concernant la création d'un vaccin efficace à plus de 90%, une nouvelle étape dans la lutte contre le COVID-19 a été franchie.

En conséquence, les médias sociaux ont réagi et les gens du monde entier ont commencé à exprimer leurs avis liés au processus de vaccination, qui n'était plus une hypothèse mais plus proche, chaque jour, de devenir une réalité.

Dans l'étude, un ensemble de données de 2 349 659 tweets a été collecté et analysé à l'aide d'algorithmes classiques d'apprentissage automatique et d'apprentissage profond.

Le nombre de tweets et la position (par exemple pour, contre ou neutre) exprimée à travers les messages Twitter concernant la vaccination ont été mis en relation avec les événements rapportés par les médias au cours de la période analysée. La correspondance entre les informations contenues dans les tweets et les événements dans les médias a été confirmée par l'analyse.

Même si la position principale était neutre au niveau quotidien et sur l'ensemble de la période (environ 70 %), avec des pourcentages similaires enregistrés pour le nombre de tweets contre (14 %) et pour (16 %), la détection précoce d'un changement d'opinion pourrait être très utile dans le contexte où de nombreux pays du monde entier envisageaient de lancer le processus de vaccination contre le COVID-19. Cette détection permettrait aux décideurs gouvernementaux de promouvoir des actions visant à limiter la diffusion de fake news et à accroître la confiance du grand public envers la vaccination. L'analyse peut être effectuée quotidiennement, afin d'avoir une vue d'ensemble en temps réel de l'évolution de la position.

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The Longest Month: Analyzing COVID-19 Vaccination Opinions Dynamics From Tweets in the Month Following the First Vaccine Announcement

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ABSTRACT The coronavirus outbreak has brought unprecedented measures, which forced the authorities to make decisions related to the instauration of lockdowns in the areas most hit by the pandemic. Social media has been an important support for people while passing through this difficult period. On November 9, 2020, when the first vaccine with more than 90% effective rate has been announced, the social media has reacted and people worldwide have started to express their feelings related to the vaccination, which was no longer a hypothesis but closer, each day, to become a reality. The present paper aims to analyze the dynamics of the opinions regarding COVID-19 vaccination by considering the one-month period following the first vaccine announcement, until the first vaccination took place in UK, in which the civil society has manifested a higher interest regarding the vaccination process. Classical machine learning and deep learning algorithms have been compared to select the best performing classifier. 2 349 659 tweets have been collected, analyzed, and put in connection with the events reported by the media. Based on the analysis, it can be observed that most of the tweets have a *neutral* stance, while the number of *in favor* tweets overpasses the number of *against* tweets. As for the news, it has been observed that the occurrence of tweets follows the trend of the events. Even more, the proposed approach can be used for a longer monitoring campaign that can help the governments to create appropriate means of communication and to evaluate them in order to provide clear and adequate information to the general public, which could increase the public trust in a vaccination campaign.

INDEX TERMS Opinion mining, social media, COVID-19, SARS-CoV-2, stance classification, vaccine.

I. INTRODUCTION

The coronavirus outbreak caused by the novel coronavirus SARS-CoV-2 has brought a series of changes in many aspects of people's economic and social life. Since its occurrence, the coronavirus pandemic has continued to monopolize the different parts of the world, reaching 220 countries and territories by December 9, 2020 [1]. Governments have tried to address the outbreak by considering a series of measures, not all of them in accordance with the general public opinion.

The associate editor coordinating the review of this manuscript and approving it for publication was Derek Abbott¹.

In all this time, the rapid growth of the number of cases globally has produced panic, fear and anxiety among people [2].

Due to the current situation generated by the lockdown in some parts of the world and social distancing in others, the use of social media globally has intensified [2], as it succeeds in connecting people from geographically different places and allows them to exchange ideas and information related to a series of aspects that have occurred in this period. Even more, people seem to rely on the information posted on social media. As a result, social media platforms have become mediator channels between each individual and the rest of the world and have gained more and more attention, being

one of the fastest growing information systems for social applications [3], [4]. On this channel, individuals show their different views, opinions and emotions during the various events that occur due to the coronavirus pandemic [3].

Among some of the well-known social media platforms, Twitter has gained a particular attention as the users can easily broadcast information about their opinions on a given topic through a public message, called tweet [5]. Besides the information voluntarily offered by the user, a tweet may also retain information related to the location of the user and might contain links, emoticons and hashtags which can help the user in better expressing his/her sentiments, making it a source of valuable information [5], [6]. Even more, Twitter has been used by government officials and political figures for informing the general public either regarding their activity or in the case of major events occurrence [7].

Over time, the information extracted from Twitter has been used in various studies, featuring, but not being limited to: analyzing public opinion related to refugee crisis [8], natural disasters and social movements [9], evaluating companies' services [10] and reputation [11], sports' fans sentiments [12], [13], forecasting the prices of cryptocurrencies [14], predicting vehicle sales [15], political attitudes in multi-party contexts [16], healthcare [17], infectious disease [3], [18], celiac disease [19] and cancer patients sentiments [20], vaccination [5].

The vaccination topic has been, over time, one of the themes which have raised a series of questions in social media, most of them related to the safety of the entire process. As a result, a series of studies have analyzed the impact of different social media campaigns on vaccination hesitancy [21]–[23] or the general public sentiment in connection with the vaccination process [5], [24]. Additionally, compared to other vaccination situations studied in the scientific literature, the COVID-19 vaccination comes with new inquietudes related to the relatively short period of time needed for the vaccine development. As known, the process of developing a vaccine typically takes a decade [25]. Note, however, that the fastest vaccine development before has been four years [26] in the case of mumps vaccine and that, almost forty years after the discovery of HIV, no effective vaccine has yet been developed. However, the vaccine timelines for COVID-19 are reduced due to the emergency [25]. On December 18, 2020, the web site COVID-19 Vaccine Tracker,¹ held by Milken Institute, shows 236 vaccines are in development, 38 are now in clinical testing and 7 have reached a regulatory decision. Nevertheless, on December 8, 2020 the first vaccine has been administrated in UK.

In this context, the present paper analyzes the public opinion related to the vaccination process in the case of COVID-19, by considering the messages posted on Twitter. The period between November 9, 2020 – when Pfizer and BioNTech announced the development of a vaccine that is more than 90% effective, to December 8, 2020 – when the vaccination

process has started in UK, has been considered. A number of 2 349 659 tweets have been collected and a cleaned dataset containing 752 951 tweets has been extracted. The performance for stance detection of several machine learning algorithms (both classical machine learning and deep learning algorithms) has been compared on an annotated dataset. The best performing algorithm has been selected and used for analyzing both the entire and the cleaned datasets.

The contribution of the paper is three-folded: we have collected and annotated a COVID-19 vaccination dataset, we have determined the best performing classifier for COVID-19 vaccination stance detection and we have put in relation the number of tweets and the stance (e.g. *in favor*, *against* or *neutral*) with the events reported by the media in the analyzed period.

The chosen approach can be easily integrated in a system which can allow interested organizations a proper monitoring of the public opinion regarding the vaccination process in the case of the new coronavirus.

The remainder of the paper is organized as follows. Section 2 provides a literature review structured in two main parts: natural language processing – focusing on sentiment analysis and stance detection from social media messages, and recent studies analyzing public opinion based on COVID-19 data extracted from Twitter. Section 3 describes the proposed methodology, while Section 4 focuses on the dataset collection and annotation process. Section 5 describes the steps required for stance detection and analyzes the performance of the classification algorithms. Section 6 presents the dynamics of opinions in the analyzed period. The limitations of the present study are mentioned in Section 7. The paper closes with a conclusion section and references. A series of supplementary materials accompany the paper, in the form of the collected and annotated datasets, along with the extracted unigrams, bigrams and trigrams for each day in the selected period.

II. LITERATURE REVIEW

In the following, a short literature review regarding sentiment analysis and stance detection is conducted in order to underline the current approaches in the research literature. Afterwards, a series of studies that have analyzed the public opinion, in the context of the COVID-19 pandemic, using data extracted from Twitter are discussed.

A. SENTIMENT ANALYSIS AND STANCE DETECTION

Opinion mining is a growing area of the Natural Language Processing field commonly used to determine viewpoints towards targets of interest using computational methods [27]. It is also known as sentiment analysis and includes many sub-tasks, such as polarity detection – in which the goal is to determine whether a text has positive, negative or neutral connotation [28], emotion identification – in which the objective is to uncover specific emotions such as happiness, fear or sadness [29], subjectivity detection – in which the goal is to determine if the text is objective or subjective [30].

¹<https://www.covid19vaccinetracker.org>

Stance detection [31], [32] is an opinion mining task used in debate analysis, for determining the opinions towards a specific target. It can be formalized as the task of identifying the tuple $\langle t, s \rangle$, in which t represents the target entity, while s represents the opinion. The target entity (t) can be any discussion topic, including products, services, economic measures, or life choices, such as vaccination. The opinion (s) towards the target is identified as *in favor*, *against* or *neutral* [27].

While similar in some respects to polarity detection, stance detection is a different natural language processing task, given the fact that positive tweets can be against the target entity, while on the contrary, negative tweets can sometimes express a favorable view of the target entity. Moreover, when compared to polarity detection, stance detection always determines the agreement or disagreement in relation to a specific target, even in cases in which the target is not explicitly mentioned in the analyzed text [5].

The types of approaches that can be used for polarity analysis and stance detection include: lexicon-based methods [33], machine learning methods [34] and hybrid methods – in which lexicons and machine learning are combined [35], [36].

Lexicon based methods rely on sentiment lexicons, such as Bing Liu's opinion lexicon [37], MaxDiff [38], Senti-ment140 [39], VaderSentiment [40], SentiWordNet [41] or SenticNet [42], which contain words and sequences of words, together with the polarity score, indicating the strength of the positive, neutral or negative perception. For performing polarity detection, the sentiment lexicons are used together with semantic methods, which typically consider negations and booster words [40]. A simple rule-based model incorporating a sentiment lexicon, as well as grammatical and syntactical conventions, called Vader, is proposed by Hutto and Gilbert [40]. The authors show that the proposed model outperforms individual human raters. When compared to classical machine learning algorithms (such as Support Vector Machines, Naïve Bayes and Maximum Entropy), the authors show that Vader offers a better performance on the datasets collected from Twitter, Amazon reviews and NYT editorials. Given the fact that the creation of lexicons is time consuming, Cotfas *et al.* [33] have shown that multiple existing lexicons can be combined to create more comprehensive lexicons through the advantages brought by the grey systems theory. Compared to machine learning, lexicon-based approaches have the advantage of not requiring the collection and annotation of training data, making them preferable when the volume or the quality of the training data is not sufficient [43], [44].

Machine Learning approaches use supervised classification algorithms to extract knowledge regarding the sentiment polarity or the stance of a text. As a preliminary step, before applying machine learning, the text needs to be first converted into numerical vectors, using schemes such as Bag-of-Words and word embeddings. The Bag-of-Words approach is a flexible text representation scheme that describes the number

of occurrences of words in the encoded document. As a disadvantage, this scheme does not consider the sequence in which the words appear in the document, thus ignoring the context in which they are used [45]. Word embeddings are a text representation approach in which each word is mapped to a vector having the values computed in such a way that allows words which frequently appear in similar contexts to have a similar representation [46]. The main benefit of this representation is that additional clues become available for the classification algorithms. Another advantage resides in the fact that the number of required dimensions is greatly reduced when compared to a sparse vector representation, such as one-hot encoding, in which each term is as a binary vector that contains only zeros, besides a single one-value, corresponding to the term's index in the vocabulary [45]. Among the most popular word embedding techniques, one can mention: embedding layer, Word2Vec [47], GloVe [48] and FastText [49].

Machine learning approaches include classical machine learning and deep learning algorithms. Frequently used classical machine learning algorithms for stance detection are Support Vector Machines (SVM) [5], [31], [50] and Naïve Bayes (NB) [5]. In the context of the "SemEval-2016 Task 6: Detecting Stance in Tweets" [51], the SVM classifier with unigram features, used as a baseline for the algorithms developed by the competing teams, has achieved an F-Score of 63.31. By incorporating also word n-grams (unigrams, bigrams and trigrams) and character n-grams (with lengths {2, 3, 4, 5}) the F-Score has increased to 68.98, higher than all the scores recorded by the algorithms proposed during the competition [51]. D'Andrea *et al.* [5] have compared several classical machine learning (including SVM and NB) and deep learning algorithms for detecting the stance towards vaccination in Italian tweets, achieving the best results when using SVM. The approach proposed by D'Andrea *et al.* [5] has constituted the basis for the current study.

Deep Learning algorithms have become particularly popular in recent years for both stance detection [31] and sentiment analysis [52]. The Deep Learning based techniques have predominantly used Convolutional Neural Networks (CNN) [5], [53] and Recurrent Neural Networks (RNN) [54], [55], with its variant Long Short-Term Memory (LSTM) [5], [56]–[58]. Zarrella and Marsh [58] have proposed a LSTM approach that has achieved an F-Score of 67.82, one of the highest scores among the competing teams at "SemEval-2016 Task 6: Detecting Stance in Tweets". However, the algorithm has performed worse than the baseline SVM n-grams algorithm.

As an alternative to RNN and CNN, Vaswani *et al.* [59] have proposed transformers, an attention-based architecture, replacing the recurrent layers with multi-headed self-attention, achieving state of the art results for machine translation [59], document generation [60] and syntactic parsing [61]. Transformer-based language models, pre-trained on large and diverse corpuses of unlabeled data, such as Generative Pre-trained Transformer (Open-AI GPT) [62] and Bidirectional Encoder Representations from Transformers

(BERT) [63] can be afterwards easily fine-tuned for a wide range of Natural Language Processing (NLP) tasks [62], [63]. While Open-AI GPT uses a unidirectional left-to-right architecture, BERT relies on a bidirectional approach, providing better results on many NLP tasks, including sentiment analysis [63].

Hybrid methods feature a combination of lexicons and machine learning algorithms. Aloufi and Saddik [35] have performed polarity detection from football-specific tweets using several machine learning algorithms and a sentiment lexicon automatically generated starting from a manually labeled dataset. Even though some improvements have been noticed by the authors in comparison to using general lexicons, the best results have been achieved by SVM with unigrams.

Comparisons between various stance analysis approaches used in social media analysis are included in Wang *et al.* [31] and Mohammad *et al.* [51].

B. TWITTER SENTIMENT ANALYSIS ON COVID-19 DATA

In the case of epidemics, Merchant and Lurie [64] have observed that besides the role assumed by social media of becoming the fastest channel of communication between people found in situations of social distancing due to lockdown, the social media can also act as a tool which can be used for anticipating the circumstances related to the spread of epidemics around the world. The authors have observed a high correlation between the information posted on Twitter regarding the evolution of an epidemic and the official data released by the Center for Disease Control and Prevention. As a result, the authors have concluded that Twitter can provide real-time estimations and predictions in the case of epidemic-related activities. Based on this research, Kaur *et al.* [65] have used the data extracted from Twitter to monitor the dynamics of emotions during the first months after the COVID-19 has become known to the public. A total number of 16 138 tweets have been extracted and analyzed using IBM Watson Tone Analyzer. As expected, the number of negative tweets exceeded the number of neutral and positive tweets in all the three months considered in the paper. Comparing the sentiments extracted for June with the ones extracted for February, it has been observed that the proportion of negative sentiments has decreased (from 43.92% to 38.05%), while the positive sentiments proportion has increased (from 21.38% to 27.01%). The proportion of the neutral sentiments has been almost the same (34.07% in February vs. 34.94% in June).

The prevalence of negative sentiments over the positive ones in the case of the COVID-19 pandemic has been also underlined by Singh *et al.* [66], while Boon-Itt and Skunkan [67] have recorded a high discrepancy between the negative sentiments (covering 77.88% of tweets) and the positive sentiments (covering the rest of 22.12%).

Xue *et al.* [68] have analyzed the public sentiment related to 11 selected topics determined using Latent Dirichlet Allocation on COVID-19 tweets. The authors have concluded that fear is the most dominant emotion in all the considered

topics and that the findings are in line with other studies on COVID-19 which state that human psychological conditions are significantly impacted by the coronavirus outbreak [68].

On the other hand, Bhat *et al.* [69] found that the most prominent sentiment was positive in the analysis conducted in their paper. The authors state that the occurrence of the positive sentiments in 51.97% of tweets can be a sign that the users who have posted the messages are hopeful and enjoy the socialization experience shared with the family in this period of lockdown and limited social interaction.

At regional level, Kruspe *et al.* [70] have analyzed geo-tagged tweets in Europe regarding COVID-19 through the use of a neural network, featuring a multilingual version of BERT, which has been trained on an external dataset, not connected to the COVID-19 outbreak. Based on their results, the authors state that they have observed a general downward trend of the negative sentiments as the time passes.

At national level, several studies have been conducted for different countries around the world. For example, in a study conducted on tweets extracted for Nepal, Pokharel [71] observed that the public opinion faced positive sentiments (58% of the tweets), while the negative sentiments have only been expressed in 15% of the tweets. The study used a Naïve Bayes model applied on a limited number of tweets (615 tweets). Barkur *et al.* [72] determined that in the case of the tweets from India, the positive sentiment was dominant when analyzing the national lockdown situation announced by the government. Similar conclusions have been reached by Khan *et al.* [73] in a research that has used Naïve Bayes classifier. The difference between the reactions towards the pandemic in different cultures has been studied by Imran *et al.* [74] through sentiment and emotion analysis, implemented with deep learning classifiers. Besides the correlation between tweets' polarity from different countries, the authors also state that NLP can be used to link the emotions expressed on social platforms to the actual events during the coronavirus pandemic. Samuel *et al.* [75] have shown insights related to the evolution of the fear-sentiment over time in the United States.

At regional level, Zhou *et al.* [76] analyzed the sentiments in local government areas located in Australia and found that the general sentiment during the COVID-19 pandemic was a positive one, but there have been observed decreases in the positive polarity as the pandemic advanced, with significant changes from positive to negative sentiments depending on the government policies or social events. Wang *et al.* [77] made a comparative analysis between the tweets posted in California and New York and concluded that California had more negative sentiments than New York and that the fluctuation in sentiment scores can be correlated with the severity of COVID-19 pandemic and policy changes. Pastor [78] analyzed the sentiment of the Filipinos located in Luzon area and concluded that most Filipinos had negative sentiments, most of them due to the extreme community quarantine.

Some other analyses on Twitter in the context of COVID-19 have focused, but have not been limited to: topical

sentiment analysis regarding the use of masks [79], monitoring depression trends [80], sentiment dynamics related to cruise tourism [81], identifying discussion topics and emotions [82], thematic analysis [83], detecting misleading information [84].

As shown above, the prominent sentiments related to COVID-19 have been found to be either positive or negative. The expressed sentiments have been shown to depend on the geographic area, government decisions and number of recorded cases. A more in-depth analysis related to the studies on sentiment analysis featuring COVID-19 and other infectious diseases can be found in Alamoodi *et al.* [3].

In this context, the present paper aims to analyze the stance of the Twitter users in connection to the new upcoming vaccines for COVID-19 in the first month after Pfizer and BioNTech announced their results on the new vaccine. The methodology and data collection process are presented in the following sections.

III. METHODOLOGY

The steps taken in order to analyze the public's opinion regarding COVID-19 vaccination from social media messages are shown in Figure 1.

The initial step is to collect a COVID-19 vaccination stance dataset containing English language tweets. A randomly sampled subset from this dataset has been afterwards manually annotated as *neutral*, *in favor*, or *against* vaccination, in order to be used in the training phase of the stance classification algorithms.

Given their unstructured nature and informal writing style, in the following step, the tweets from the collected dataset have been pre-processed, with the purpose of improving the performance of the stance classification algorithms.

For text representation and classification, four approaches have been investigated: 1) Bag-of-Words representation followed by classical machine learning, 2) Word embeddings followed by classical machine learning, 3) Word embeddings followed by deep learning and 4) Bidirectional Encoder Representations from Transformers.

In order to determine the best performing classification algorithm, the text has been represented using both Bag-of-Words and word embeddings schemes. In the present paper, the performance of multiple classical machine learning and deep learning algorithms has been evaluated based on the following widely used metrics: Accuracy, Precision, Recall and F-score. Accuracy, which indicates the ratio of correctly predicted observations to the total observations is defined as shown in (1), in which TP, TN, FP and FN refer to true positive, true negative, false positive and false negative. Thus, TP represents the number of real positive tweets classified as positive, FP is the number of real negative tweets classified incorrectly as positives, TN represents the number of negative tweets correctly classified as negative and FN is the number of real positive tweets incorrectly classified as negative.

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

Precision, which represents the ratio of correctly predicted positive observations to the total predicted positive observations, is computed as shown in (2).

$$\text{Precision} = \frac{TP}{TP + FP} \quad (2)$$

Recall, representing the ratio of correctly predicted positive observations to all the observations in the actual class, is computed as shown in (3).

$$\text{Recall} = \frac{TP}{TP + FN} \quad (3)$$

Starting from Precision and Recall, the F-Score can be computed as a weighted average, as shown in (4).

$$F - \text{score} = 2 \cdot \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}} \quad (4)$$

Finally, the best performing algorithm has been used to analyze the evolution of the public stance towards vaccination in the considered period. The evolution has been correlated with the major events and news that have followed the announcement of the Pfizer and BioNTech vaccine results.

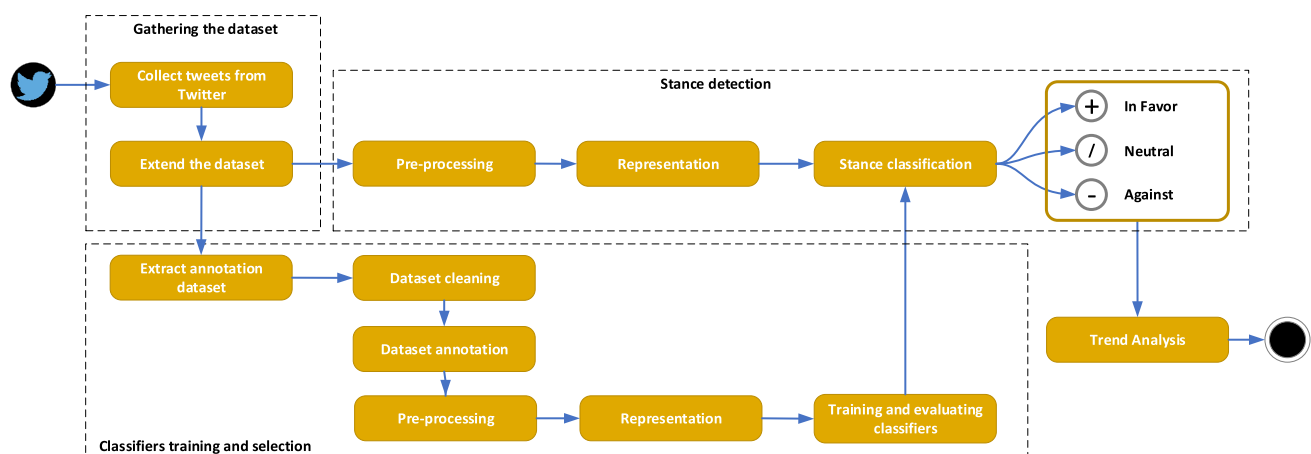


FIGURE 1. Steps of the proposed stance-detection approach.

IV. COVID-19 VACCINE STANCE DATASET

A machine learning approach has been chosen for detecting the stance of the tweets, which requires a labeled dataset for training the classification models. Since we have not identified an already labeled dataset for stance towards COVID-19 vaccination in the scientific literature, a domain-specific dataset, having Twitter as a data source, has been collected and manually annotated. It should be also mentioned, that according to [31], there is a general lack of annotated corpora for stance detection.

A. DATASET COLLECTION

Several public datasets including large-scale collections of tweets related to the coronavirus pandemic have been proposed in the scientific literature, including the ones presented in [85]–[88]. Some of the datasets, such as [86], [88], are multi-lingual, while others, such as [85], [87] are language specific, including only tweets written in English.

In order to collect a dataset centered around COVID-19 vaccination, a hybrid approach has been chosen, in which the tweets that we have fetched through the Twitter API for the keywords in Table 1, have been supplemented with the ones in the dataset described in [86], selected using the same keywords.

Gathering the tweets from the Twitter API has been performed through the Twitter Filtered Stream API, with the help of the TweetInvi² library.

While the approach proposed in this paper can be extended to other languages, in the present study only tweets written in English have been considered. Thus, between

²<https://github.com/linvi/tweetinvi>

TABLE 1. Set of keywords used to fetch tweets.

Topic	Keywords
covid-19	covid19, covid-19, coronavirus, coronaoutbreak, coronaviruspandemic, wuhanvirus, 2019nCoV
vaccination	vaccine, vaccination, vaccinate, vaccinating, vaccinated

TABLE 2. Number of vaccine related tweets published in the considered period.

Date	Nov. 9	Nov. 10	Nov. 11	Nov. 12	Nov. 13	Nov. 14	Nov. 15	Nov. 16	Nov. 17	Nov. 18
Tweets	57 265	109 839	85 901	75 341	72 512	41 387	41 335	159 611	79 275	110 131
Cleaned	56 768	29 693	22 583	19 690	19 854	11 103	11 873	38 072	23 814	28 148

Date	Nov. 19	Nov. 20	Nov. 21	Nov. 22	Nov. 23	Nov. 24	Nov. 25	Nov. 26	Nov. 27	Nov. 28
Tweets	58 878	59 674	37 816	44 717	99 690	62 186	44 621	35 807	55 701	52 977
Cleaned	19 530	21 036	12 733	13 940	31 514	22 300	15 246	12 236	15 425	13 469

Date	Nov. 29	Nov. 30	Dec. 1	Dec. 2	Dec. 3	Dec. 4	Dec. 5	Dec. 6	Dec. 7	Dec. 8
Tweets	35 497	82 639	51 407	154 004	135 162	97 410	69 856	64 438	122 134	216 822
Cleaned	11 704	21 697	19 719	49 589	45 288	32 345	21 428	20 104	31 851	60 199

November 9 and December 8 a number of 2 349 659 tweets concerning the topic of COVID-19 vaccination have been identified.

B. DATASET ANNOTATION

To ensure the quality of the annotated dataset, that will be used for training the machine learning algorithms, duplicated tweets have been discarded, as well as retweets. The retweets have been easily identified due to the presence of the “RT” symbol. This choice is in accordance with the approach from other studies, including, but not limited to [5], [35]. The remaining number of tweets in the cleaned dataset is 752 951, representing 32.04% of the initial dataset. Table 2 includes for each day in the considered period both the total number of tweets, as well as the remaining number of tweets after the duplicates and retweets have been eliminated.

From the cleaned dataset we have randomly selected and manually annotated 7530 tweets, representing approximately 1.00% of all the tweets in the dataset. The number is higher than the one used in other stance detection approaches, such as D’Andrea *et al.* [5] and Mohammad *et al.* [89]. D’Andrea *et al.* [5] have trained the algorithms on a manually labeled dataset containing 693 tweets. The dataset proposed by Mohammad *et al.* [89] is organized on several topics, with the largest topic numbering 984 tweets.

In the present approach, the stance of the tweets towards vaccination has been evaluated by three independent human raters into three classes: *in favor*, *against* and *neutral*. Disagreements between the annotated tweets have only been recorded between the *in favor* and *neutral* or between the *neutral* and *against* stances. No disagreement has been recorded between *in favor* and *against* annotations. In the case of disagreement, the class chosen by most annotators has been associated with the tweet.

The distribution of the tweets in the annotated dataset in the three considered categories is illustrated in Table 3.

Tweets that have been assigned to the class *in favor* express a positive opinion regarding the vaccination. Tweets belonging to the *against* vaccination class express a negative opinion towards COVID-19 vaccination. The *neutral* class

TABLE 3. Statistics for the manually annotated dataset.

Class	Number	Percent
<i>against</i>	1083	14.38%
<i>neutral</i>	5188	68.90%
<i>in favor</i>	1259	16.72%
Total	7530	100.00%

mainly includes news related to the development of vaccines, tweets that do not express a clear opinion, such as questions regarding the vaccine, informative tweets concerning vaccination, as well as off-topic tweets, many of them related to the 2020 presidential election in the United States, which was held nominally, just a few days before the analyzed period, on November 3, 2020. Several examples of manually labeled tweets belonging to the three categories are included in Table 4.

The n-grams and balanced annotated dataset are available at the following link: <https://github.com/liviucotfas/covid-19-vaccination-stance-detection>

V. COVID-19 VACCINATION STANCE DETECTION

The main components of the stance detection process are the pre-processing, the feature extraction and the machine learning classification. In the pre-processing step the text is cleaned, while in the feature extraction the raw textual data is converted to feature vectors. The classical machine learning and deep learning classifiers, that have been compared in this paper, are described within this section.

A. PRE-PROCESSING

Given the fact that social media messages are frequently written using a casual language, a pre-processing step has been used in order to prepare the tweets in the annotated dataset for training the machine learning classifiers. This step is considered crucial by D'Andrea *et al.* [5] for the success of the entire system, while Bao *et al.* [90] provide a comprehensive discussion regarding the importance of pre-processing in social media analysis. The impact of the different pre-processing steps, such as the removal of links, on the performance of classical machine learning classifiers has been discussed by Jianqiang and Xiaolin [91].

During this pre-processing step, all the user mentions, easily identified through the presence of the @ symbol at the beginning of the message have been normalized, since they do not provide any useful information for the classification process. All the links and email addresses have been normalized as well. The emoticons have been replaced with the corresponding words. Minor spelling mistakes have been automatically corrected to improve performance. Contractions and hashtags have been unpacked, while elongated words have been corrected and annotated. Finally, all the letters have been converted to a lowercase representation. The pre-processing has been implemented with the help of the ekphrasis library [92]. Additional processing has been performed through Natural Language Toolkit (NLTK) library [93] and the “re” python module.

B. FEATURES

In order to use machine learning algorithms for text classification, the text content has to be first converted into

TABLE 4. Examples of tweets *against*, *neutral* and *in favor*.

Stance	Tweet
<i>against</i>	🤔 WHY would i take a vaccine for a bug that the CDC says i have a 99% chance against, with just my God given immune system? I have a bigger chance of dying from a car accident or a bee sting. https://t.co/yIGR1HhzLe ▶▶▶▶
	Do you want to be a guinea pig for a virus that 97% of people survive? Why is there even a vaccine for an illness with such a high survival rate? https://t.co/TsaMidiABr
	No way!!! Over my dead body, I won't have a vaccine in my body, why would I.. I'm healthy!!!! 🙏 #NoVaccine #FreedomFirst #mybodymychoice 🤔🤔🤔🤔🤔🤔🤔 https://t.co/GQ9VFHPbjZ
	People cheering for the nano tech infested vaccines. Humanity has reached a level of stupidity that is truly mind blowing 🤖 https://t.co/uUj29ejXtY
<i>neutral</i>	Italy will receive an initial 3.4 mln shots of the Pfizer coronavirus vaccine,probably in January,a government source told Reuters on Tuesday. The country will be allocated some 13.6% of the first 200 million doses made available to Europe, the source said. https://t.co/LftlQ1WYmn https://t.co/ueeH407K4I
	So how does the Pfizer Covid-19 vaccine injection work? Do they inject it at -90 degrees F. ? 🤔
	#Covid19 vaccine is here 🍷 https://t.co/xK3UMSENN1
<i>in favor</i>	Airlines scramble to prepare for ultra-cold COVID-19 vaccine distribution https://t.co/isvziZG0hi https://t.co/OATFux2Npq
	Omg 90% effective coronavirus vaccine ???? Light at the end of the tunnel ! so you're telling me there a CHANCE that I can actually walk graduation 🎓
	All I want for Christmas is covid19 vaccine. 🤔🤔🤔 https://t.co/WKThNeYWYr
	Kudos to all the scientists and medical experts working tirelessly to produce a safe and productive vaccine to defeat COVID-19 🙏 I want someone to find a damn vaccine or cure for this STUPID VIRUS man. Tired of seeing it affect families and kill ppl. Tired of walking past the ICU of my job seeing folks fighting for their lives. Sick of these lingering effects from me having it. SICK OF COVID-19 🤔🤔🤔

numerical feature vectors. The Bag-of-Words (BoW) scheme converts the text to a numerical representation, having as a starting point the frequency of the words. Given a vocabulary $V = \{w_1, \dots, w_N\}$, containing N tokens, denoted using w_i , a tweet, or any other textual document d , belonging to a corpus D , can be represented using a feature vector $X = \{x_1, \dots, x_N\}$, in which x_i can either represent a binary variable that indicates whether the word w_i appears in the text or a numeric variable indicating the number of times the word w_i appears in the text.

Given the fact that very frequent words can sometimes carry little “informational content”, the performance of classification algorithms that rely on word frequencies can be improved using a more complex feature representation, called Term Frequency - Inverse Document Frequency (TF-IDF), that reduces the weight associated to words that frequently appear in all the documents in the corpus. TF-IDF is computed as shown in (5):

$$TF - IDF_{(w_i)} = TF_{(w_i)} \times \log \frac{|D|}{DF_{(w_i)}} \quad (5)$$

where $TF_{(w_i)}$ represents the number of appearances of the word w_i , $|D|$ stands for the number of documents and $DF_{(w_i)}$ is the number of documents containing the term w_i . The TF-IDF statistical measure is used throughout the present study for features representation.

By only focusing on the number of times a word occurs in a given text, the Bag-of-Words approach does not provide any information regarding the succession of the words. This issue can be addressed if the n-gram language model is used, in which the text is represented through successions of N consecutive words. Common types of n-grams include grams of size one, called unigrams (1-grams), grams of size two, called bigrams (2-grams), and grams of size three, called trigrams (3-grams) [94].

In the present study, various combinations of unigrams, bigrams and trigrams have been considered as features for the machine learning algorithms, as shown in Table 5.

TABLE 5. N-gram combinations.

N-gram model	Types of n-grams
(1-1)	unigrams
(1-2)	unigrams + bigrams
(1-3)	unigrams + bigrams + trigrams
(2-2)	bigrams
(2-3)	bigrams + trigrams
(3-3)	trigrams

Besides the Bag-of-Words representation, word embeddings have been used. In word embeddings the words are mapped to vectors, having similar representations for the words which frequently appear in the same context. Compared to one-hot encodings, word embeddings provide a denser representation that requires a smaller number of

dimensions for representing the words. The similar representation of words with close meanings provides additional clues for the classification algorithms. The following word embeddings have been considered in the present study: Datastories,³ GloVe⁴ and Fast-Text.⁵

C. LEARNING ALGORITHMS

A machine learning approach has been used in order to accurately determine the stance towards vaccination in the collected tweets. Starting from the annotated dataset, the performance of several popular classification algorithms has been investigated: Multinomial Naive Bayes (MNB), Random Forest (RF), Support Vector Machine (SVM), Bidirectional Long Short-Term Memory (Bi-LSTM) and Convolutional Neural Network (CNN).

1) MULTINOMIAL NAIVE BAYES

Naive Bayes classifiers are a family of probabilistic classification algorithms that apply the Bayes theorem. They are called naive because they perform the classification under a strong assumption that every feature is independent from the other features. Despite their simplicity, this family of algorithms has been demonstrated to be fast, reliable and accurate in many NLP classification tasks [95]. The Multinomial Naive Bayes [96] classifier implements a variant of the Naive Bayes algorithm which can be used with multinomially distributed data, such as the frequencies of n-grams in text classification problems.

2) RANDOM FOREST

Random Forest (RF) [97] is an ensemble classifier that consists of multiple decision tree classifiers, trained in parallel with bootstrapping followed by bagging. According to Misra and Li [98] the RF classifier offers better results when compared to other classification methods in terms of accuracy and does not require feature scaling. Furthermore, the RF classifier has been determined to be more robust in the selection of training samples. Even though the RF might be hard to interpret, its hyperparameters can more easily be turned than in the case in which a decision tree classifier is used [98].

3) SUPPORT VECTOR MACHINE

Support Vector Machines (SVM) [99] are a family of supervised learning algorithms used for classification, regression and other tasks such as outlier detection. While other classification algorithms suffer from overfitting, one of the advantages of SVM is that they are less prone to this situation [100]. Another advantage resides in the fact that besides binary classification, multiclass classification can be performed by combining several binary classification functions. For this, each class is considered individually at a time, and for each

³<https://github.com/cbaziotis/datastories-semeval2017-task4>

⁴<https://nlp.stanford.edu/projects/glove>

⁵<https://fasttext.cc/docs/en/english-vectors.html>

class a classifier is searched that separates it from the other classes [101].

4) LONG SHORT-TERM MEMORY

The Long Short-Term Memory (LSTM) [102] is a type of Recurrent Neural Network (RNN). In the current paper, a bidirectional LSTM approach has been used (Bi-LSTM), that follows the architecture proposed by Baziotis *et al.* [92], which has ranked among the best two submissions at “SemEval-2017 Task 4” [103]. The architecture consists of the following layers: word embedding (none, 50, 300), Gaussian noise (none, 50, 300), bidirectional LSTM (none, 50, 300), bidirectional LSTM (none, 50, 300), attention (none, 300), dropout (none, 300), dense (none, 3) and activation (none, 3). The Gaussian noise and bidirectional LSTM layers are followed by dropout (none, 50, 300) layers.

5) CONVOLUTIONAL NEURAL NETWORK

Convolutional Neural Networks (CNN) are a type of neural networks that are specialized for processing data that features a grid-like topology [46]. CNNs have already been successfully used in different NLP tasks, including stance classification [5], [104], [105].

In the current paper, we have followed the approach used by Cliché [104] and Baziotis *et al.* [106] regarding the filter lengths of [3]–[5]. Additionally, the architecture of the network is similar to the one presented in [106]. In the approach used in the current paper, the word embedding layer (none, 50, 300) is followed by a Gaussian noise layer (none, 50, 300) and by a dropout layer (50, 300). After this layer, three 1-D convolutional layers (using ReLU activation) have been added, each followed by a max pooling layer and a flattening layer. The outputs of these layers are merged in a concatenation layer (none, 7000). The dropout layer (none, 7000) and a dense layer (none, 3) conclude the network.

6) BIDIRECTIONAL ENCODER REPRESENTATIONS FROM TRANSFORMERS

Bidirectional Encoder Representations from Transformers (BERT) [63] is a pre-trained transformer-based language model. Compared to word embeddings such as GloVe, BERT has the advantage of taking into account the context for each occurrence of a given word. The model has been pre-trained on a diverse corpus of unlabeled text extracted from the English Wikipedia and the BookCorpus [107].

Pre-trained BERT models with a wide range of sizes exist, varying the number of layers L from 2 to 24 and the hidden size H from 128 to 1024 [63], [108]. In the present paper, the BERT_{BASE}⁶ model has been chosen, having $L = 12$, $H = 768$ and the number of self-attention heads $A = 12$. The neural network architecture has a total of 110M parameters. In comparison, BERT_{LARGE} ($L = 24$, $H = 1024$, $A = 16$), having 340M parameters, has been shown to provide

improvements in accuracy of no more than 5% [63], while being far more compute intensive.

D. EXPERIMENTS AND RESULTS

The classical machine learning algorithms have been implemented using the scikit-learn [109] library, while the deep learning algorithms have been implemented using the Keras⁷ library, having TensorFlow⁸ as a backend.

Cross-validation using either 5-folds [51] or 10-folds [5] is a widely-used approach for comparing and selecting classifiers. In this paper, following the approach described by Mohammad *et al.* [51], the classifiers have been evaluated through a 5-fold cross-validation procedure, during which the classification model is trained using $k-1$ of the folds as training data, while the resulting model is validated on the remaining part of the data. The performance of the classifier is then computed as an average of the values computed during the k consecutive runs. Since the balanced dataset includes 3249 tweets (1083 in each class), at each iteration, the classification models are trained using 2600 tweets and evaluated using the remaining 649 tweets. The results of the considered methods are shown in Table 6 and further discussed in the sub-sections below.

1) BOW AND CLASSICAL MACHINE LEARNING

The best parameters for the developed natural language processing pipeline have been determined through the grid search approach. Thus, different numbers of features have been tested, including using all the features and reducing the number of features, F , to a maximum of 1500, 2000 and 3000 values.

Different n -gram combinations, ranging from (1,1) to (1,3), as listed in Table 5, have been investigated for the string vectorizer, as well. Additionally, the algorithms have been evaluated considering both the case in which the general stop words are kept and the one in which they are excluded. The stop word list that has been considered is the one included in the NLTK library. In the case of the corpus-specific stop words, the document frequency thresholds, maxDF, that have been considered are 0.5, 0.75 and 1.0. Besides, the evaluation has also analyzed whether applying Term Frequency (TF) or Term Frequency - Inverse Document Frequency (TF-IDF) can improve the stance classification results.

We have experimented with different settings for the classifiers, including varying, in the case of the SGDClassifier, the alpha parameter, which multiplies the regularization term. Different regularization terms have been tested, including “l1”, “l2” and “elasticnet”. The loss function of the SGDClassifier has been configured as “hinge”, corresponding to a linear SVM.

For each considered classical machine learning classifier (C1-C6), Table 6 includes both the results achieved using the parameters determined through grid search (C1, C3, C5)

⁶<https://huggingface.co/bert-base-uncased>

⁷<https://keras.io>

⁸<https://www.tensorflow.org>

TABLE 6. Classification performance.

Code	Classifier	Class	Precision	Recall	F-score	Accuracy
C1	MNB n-gram: (1, 2); features: 3000	<i>against</i>	70.57%	83.74%	76.59	73.71%
		<i>neutral</i>	79.80%	72.20%	75.78	
		<i>in favor</i>	71.77%	65.20%	68.31	
C2	MNB n-gram: (1, 2); features: 2000	<i>against</i>	70.86%	83.37%	76.58	73.34%
		<i>neutral</i>	78.34%	73.50%	75.82	
		<i>in favor</i>	71.51%	63.16%	67.04	
C3	RF n-gram: (1, 1); features: all	<i>against</i>	67.99%	83.10%	74.77	71.71%
		<i>neutral</i>	76.19%	73.13%	74.60	
		<i>in favor</i>	72.20%	58.91%	64.84	
C4	RF n-gram: (1, 2); features: 2000	<i>against</i>	69.39%	81.25%	74.84	70.79%
		<i>neutral</i>	71.50%	74.70%	73.04	
		<i>in favor</i>	72.12%	56.42%	73.04	
C5	SVM n-gram: (1, 2); features: all	<i>against</i>	74.43%	84.03%	78.93	76.23%
		<i>neutral</i>	80.50%	76.18%	78.25	
		<i>in favor</i>	74.21%	68.52%	71.20	
C6	SVM n-gram: (1, 2); features: 2000	<i>against</i>	73.09%	78.76%	75.80	74.20%
		<i>neutral</i>	76.84%	77.84%	77.32	
		<i>in favor</i>	72.74%	66.03%	69.16	
C7	SVM word embedding: glove.6B.100d	<i>against</i>	70.79%	73.70%	71.45	68.88%
		<i>neutral</i>	72.39%	74.51%	73.14	
		<i>in favor</i>	66.44%	58.46%	60.95	
C8	Bi-LSTM word embedding: datastories.twitter.300d	<i>against</i>	74.62%	72.83%	73.65	73.41%
		<i>neutral</i>	78.74%	76.38%	77.48	
		<i>in favor</i>	67.66%	71.10%	69.20	
C9	Bi-LSTM word embedding: glove.twitter.27B.200d	<i>against</i>	74.85%	77.80%	76.04	74.70%
		<i>neutral</i>	79.75%	76.26%	77.79	
		<i>in favor</i>	70.30%	70.19%	70.17	
C10	Bi-LSTM word embedding: fasttext.wiki-news-300d	<i>against</i>	60.43%	87.59%	71.24	68.36%
		<i>neutral</i>	79.02%	70.94%	74.55	
		<i>in favor</i>	72.48%	47.16%	56.91	
C11	CNN word embedding: datastories.twitter.300d	<i>against</i>	70.50%	60.48%	64.65	65.71%
		<i>neutral</i>	68.97%	75.38%	72.02	
		<i>in favor</i>	58.94%	61.57%	59.95	
C12	CNN word embedding: glove.twitter.27B.200d	<i>against</i>	71.19%	66.13%	68.26	68.91%
		<i>neutral</i>	71.04%	77.80%	74.21	
		<i>in favor</i>	65.31%	62.65%	63.68	
C13	CNN word embedding: fasttext.wiki-news-300d	<i>against</i>	67.72%	71.17%	69.26	69.01%
		<i>neutral</i>	72.17%	77.50%	74.66	
		<i>in favor</i>	66.63%	58.20%	62.07	
C14	BERT	<i>against</i>	74.55%	84.52%	79.20	78.94%
		<i>neutral</i>	86.27%	79.07%	82.34	
		<i>in favor</i>	77.53%	73.29%	75.28	

and the results achieved through the n-gram model (1, 2), corresponding to unigrams and bigrams, and limiting the maximum number of features to $F = 2000$. For the C1-C6 classifiers, the best results have been achieved when using TF-IDF, without excluding the general stop words.

In the case of the Multinomial Naïve Bayes classifier (C1 and C2) the best results have been achieved for the C1 classifier, for which the maximum number of features has been reduced to $F = 3000$, while including both unigrams and bigrams as features, keeping $\text{maxDF} = 1.0$.

It has been observed that the Random Forest classifier (C3 and C4) performed best when using only unigrams, without limiting the number of features, while applying a

frequency threshold, maxDF , for corpus specific stop words of 0.5, namely in the case of C3.

In the case of the Support Vector Machines classifier (C5 and C6), the best results have been achieved in the case of C5, configured with the n-gram model (1, 2), without limiting the maximum number of features, an alpha parameter value of 0.0001, a maxDF threshold equal to 1.0 and choosing “elasticnet” as a regularization term.

As expected, C1, C3 and C5, for which the parameters have been determined through grid search have performed better than the corresponding classifiers of the same type, C2, C4 and C6.

The overall best performing classifier has been C5, a SVM classifier which had 76.23% accuracy, followed by C6, with

74.20% accuracy. In terms of precision and F-score, C5 overperformed all the other classifiers for each of the three considered classes, *in favor*, *against* and *neutral*. A small difference is recorded in the case of recall, where the value for the *neutral* class is slightly lower for C5 than for C6 (76.18% versus 77.84%).

The worst performing classifier has been C4, a RF classifier, with an accuracy of 70.79%. In terms of precision and recall, the classifier C4 performed worse than C5 and C6 on all three classes, *in favor*, *against* and *neutral*.

2) WORD EMBEDDINGS AND CLASSICAL MACHINE LEARNING

Starting from the algorithm that has provided the best results in the context of the Bag-of-Words approach, C5, in the following we have analyzed if the performance can be further improved by considering pre-trained word embeddings. Similar approaches, using word embeddings with classical machine learning algorithms, have been investigated in [5] and [110].

To this end, a word embedding, called glove.6B, that includes six billion tokens, created through the Glove approach from a corpus extracted from Wikipedia and from the news archive Gigaword [111], has been used. This implementation is marked in Table 6, as C7.

As shown in Table 6, the values of all the four considered metrics (precision, recall, F-score and accuracy) of the C7 classifier are worse than those achieved in the case of C5.

3) WORD EMBEDDINGS AND DEEP LEARNING

In the case of the deep learning classifiers, in the present paper, the Adam approach has been applied for tuning the learning rate [112]. The resulting classifiers are listed in Table 6 under the C8 – C13 classifiers.

As shown in Table 6, among the Bi-LSTM classifiers (C8-C10), the best results have been achieved by the C9 classifier, with an accuracy of 74.70%, higher than in the case of C8, (73.41%) and C10 (68.36%). The C9 classifier has used the word embeddings created through the Glove approach from a corpus composed of 2 billion tweets.

In the case of CNN classifiers (C11-C13) the best results have been achieved by the C13 classifier, using the word embedding created through the FastText approach on a corpus extracted from Wikipedia and news stories (accuracy 69.01%).

Classifiers C8 and C11, ranked second in the Bi-LSTM category (73.41%) and third in the CNN category (65.71%) based on accuracy, have used the Datastories word embeddings, created from a corpus of 330 million tweets, by applying the GloVe approach.

The best performing deep learning classifier has been C9, implementing Bi-LSTM, which outperforms C8, C10-C13 classifiers, both in terms of accuracy and F-score.

4) BIDIRECTIONAL ENCODER REPRESENTATIONS FROM TRANSFORMERS

In order to establish the best values for the hyperparameters of the BERT language model (C14), the approach recommended by Devlin *et al.* [63] has been followed during the fine-tuning procedure in regarding the batch sizes (16, 32), learning rate (5e-5, 3e-5, 2e-5) and number of epochs (2, 3, 4). The best results have been achieved when using a batch size of 16, a learning rate of 3e-5 and a number of epochs equal to 3. Having an accuracy of 78.94%, the C14 classifier outperforms all the other classifiers. Moreover, it clearly outperforms the second-best performing classifier, C5, in terms of precision, recall and F-score, for all the considered classes.

E. DISCUSSION

The results achieved by the deep learning classifier C9 are worse than the ones obtained in the case of the classical machine learning classifier C5 in terms of accuracy and F-score. This result is consistent with the ones in other studies, such as D'Andrea *et al.* [5], in which classical machine learning algorithms have outperformed deep learning approaches, such as CNN and LSTM, in the case of vaccine stance classification.

As noted in the review paper of Wang *et al.* [31], stance detection approaches typically do not perform extremely well. The reasons mentioned by the authors include the sparsity, the colloquial language and the absence of large, labeled datasets that could be used for training. Moreover, Mohammad *et al.* [51] summarize the results of the “SemEval-2016 Task 6: Detecting Stance in Tweets” mentioning that the SVM baseline with n-grams has performed relatively well compared to other machine learning approaches.

In the following we have used the best performing classifier, C14, to analyze the tweets collected over the considered period of time. The model has been trained on all the tweets in the annotated dataset.

VI. ANALYZING SOCIAL MEDIA

The evolution of the daily number of tweets is discussed in this section in connection with the major events which have occurred around the world related to COVID-19 vaccination, with an accent on the English-speaking countries.

A. MAJOR EVENTS

The major events have been extracted from the news published online in each day of the analyzed period using google.com search engine by selecting the “News” section and “COVID” keyword and by pointing one-by-one the days in the mentioned period. Each time, the first 10 pages of News titles have been considered and the most relevant news have been extracted in connection to the COVID-19 vaccination theme, relevance being given by the connection to the COVID-19 vaccination and the amount of news on a specific topic.

As a result, it has been observed that in all the analyzed days there have been news regarding the COVID-19 vaccination theme, starting from the announcement of the vaccine effectiveness by different producers, the amount of money funded by various organizations for COVID-19 vaccine, adverse events encountered in the pre-test phase, ethical issues related to whom should have first access to the vaccine, the predicted quantity of vaccines to be distributed in different countries and areas and ending with the vaccination in Russia and UK.

The following events have been put in connection with the number of tweets recorded daily, which might have determined the variation in the tweets' number:

- E1. Nov. 9: Pfizer and BioNTech announcement regarding their COVID-19 vaccine effectiveness⁹
- E2. Nov. 10: Positive news regarding stock trading, oil futures and cruise bookings rise as a result of COVID-19 vaccine^{10,11}
- E3. Nov. 13: World Health Organization exceeded the target of \$ 2 billion to buy and distribute COVID-19 cures to poorer countries¹²
- E4. Nov. 16: Moderna's COVID-19 vaccine shows 94.5% efficiency in clinical trials¹³
- E5. Nov. 18: Sinovac's COVID-19 vaccine induces a quick immune response¹⁴
- E6. Nov. 20: Pfizer's announcement regarding COVID-19 vaccine emergency authorization¹⁵
- E7. Nov. 23: Oxford AstraZeneca COVID-19 vaccine shows an up to 90% efficacy¹⁶
- E8. Nov. 27: UK hospitals start preparing for the arrival of the COVID-19 vaccine in 10-day time¹⁷
- E9. Nov. 30: Moderna seeks approval for the COVID-19 vaccine in Europe and United States¹⁸

⁹<https://www.cnbc.com/2020/11/09/covid-vaccine-pfizer-drug-is-more-than-90percent-effective-in-preventing-infection.html> (accessed December 9, 2020)

¹⁰<https://www.cnbc.com/2020/11/10/cruise-bookings-rise-on-coronavirus-vaccine-news-norwegian-cruise-line-ceo-says.html> (accessed December 9, 2020)

¹¹<https://in.reuters.com/article/global-oil/oil-gains-after-stockpile-draw-amid-hopes-for-coronavirus-vaccine-idINL4N2HX006> (accessed December 9, 2020)

¹²<https://uk.reuters.com/article/uk-health-coronavirus-vaccines-covax-idUKKBN27T138> (accessed December 9, 2020)

¹³<https://www.ft.com/content/9d7a2e24-aea0-4c45-82ab-509dc80ed5a1> (accessed December 9, 2020)

¹⁴<https://www.reuters.com/article/uk-health-coronavirus-sinovac/sinovacs-covid-19-vaccine-induces-quick-immune-response-study-idUKKBN27x35I> (accessed December 9, 2020)

¹⁵<https://www.technologyreview.com/2020/11/20/1012391/pfizer-authorization-covid-19-vaccine-christmas/> (accessed December 9, 2020)

¹⁶<https://www.theguardian.com/society/2020/nov/23/astrazeneca-says-its-coronavirus-vaccine-has-70-per-cent-efficacy-covid-oxford-university> (accessed December 9, 2020)

¹⁷<https://www.theguardian.com/world/2020/nov/27/hospitals-england-told-prepare-early-december-covid-vaccine-rollout-nhs> (accessed December 9, 2020)

¹⁸<https://www.bbc.com/news/health-55129336> (accessed December 9, 2020)

E10. Dec. 2: UK authorize the Pfizer BioNTech COVID-19 vaccine¹⁹

E11. Dec. 3: The first batch of vaccines arrived in UK²⁰

E12. Dec. 8: UK starts COVID-19 vaccination²¹

In order to validate the correspondence between the events and the analyzed tweets we have extracted for each date in the analyzed period the unigrams, bigrams and trigrams sorted according to the number of appearances. The analysis has been performed for both the cleaned dataset and the whole dataset, that also includes the retweets. Before the n-gram extraction, the tweets have been minimally pre-processed by removing stop words and duplicated white spaces.

From the events presented above, we have selected two events, one that has generated a large number of tweets, namely E10, and another one that has generated a comparatively smaller number of tweets, namely E6.

Analyzing the n-grams for the 1547004 tweets collected for December 2, the day of E10, it has been observed that among the top-15 unigrams, besides the specific COVID-19 terms (e.g. "vaccine", "covid", "19", "coronavirus", "covid19", "vaccines") in this day "Pfizer" has been referred 577342 times, followed by "UK" referred 48 789 times, "first" referred 39 438 times, "BioNTech" referred 30 993 times and "approve" referred 18 949 times. Based on the top-10 bigrams and trigrams, it can be observed the occurrence of the following words' combinations: "Pfizer BioNTech" referred 29 714 times, "first country" referred 18 085 times, "approve Pfizer" referred 15 453 times. Considering the extracted unigrams, bigrams and trigrams and the E10 event, UK authorization of the Pfizer and BioNTech COVID-19 vaccine, it can easily be noted that there exists a correspondence between E10 and the analyzed tweets from December 2.

On November 20, there have been collected 59 674 tweets. From the top-15 unigram analysis, the following have been extracted: "Pfizer" (17 639 times), "emergency" (13 466 times), "authorization" (7251 times), "fda" (6622 times) and "BioNTech" (5347 times). As for the top-10 bigrams and trigrams, the words' combinations have been: "emergency use" (9613 times), "use authorization" (4769 times), "emergency use authorization" (4768 times) and "Pfizer BioNTech" (4583 times). It can thus be observed that even in the case of a less significant event ("Pfizer's announcement regarding COVID-19 vaccine emergency authorization") the correspondence between the tweets and the event exists.

B. STANCE ANALYSIS

In the following, the best performing classifier - determined in Section V, BERT (C14) - is used to perform stance analysis on the gathered dataset. As it will be observed, not all the

¹⁹<https://www.economist.com/science-and-technology/2020/12/01/britain-becomes-the-first-country-to-license-a-fully-tested-covid-19-vaccine> (accessed December 9, 2020)

²⁰<https://www.bbc.com/news/uk-55181665> (accessed December 9, 2020)

²¹<https://www.bbc.com/news/uk-55227325> (accessed December 9, 2020)

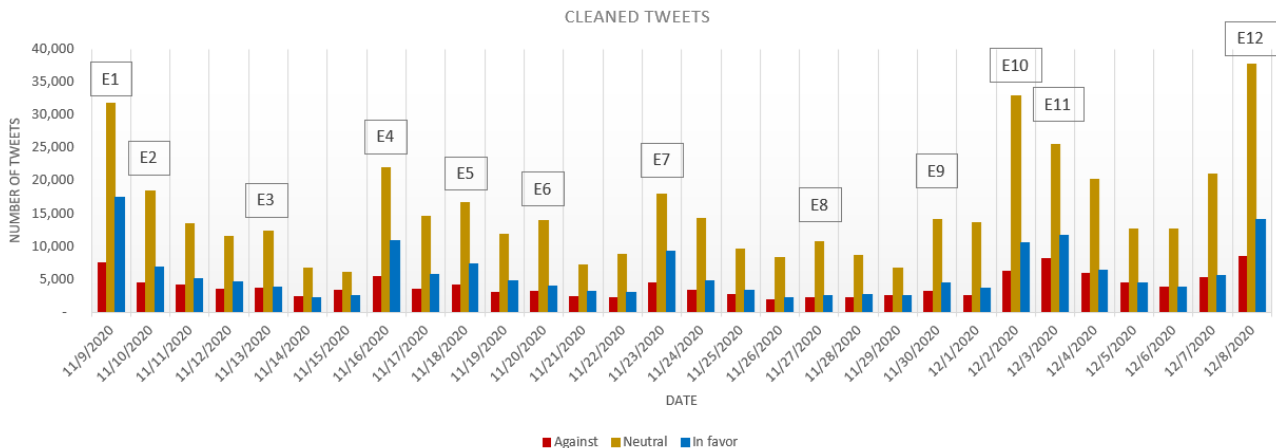


FIGURE 2. Evolution of the cleaned tweets stance.

news published in the analyzed period have generated the same amount of interest from the general public, a series of local peaks being identified in some of the analyzed days.

1) CLEANED TWEETS STANCE ANALYSIS

The evolution of the stance expressed and the distribution of the stances on the three considered categories: *in favor*, *against* and *neutral* is depicted in Figure 2, which considers only the cleaned tweets. By simply considering the stances' evolution, one can easily observe that there have been variations in the number of tweets published, especially in the days following a major announcement or news.

From Figure 2 it can be observed that the general dominating stance is *neutral*, as it was expected from the initial stage in which most of the annotated tweets belonged to this category. Based on the tweets in the *neutral* category, it has been noticed that most of them deal with presenting news related to the occurrence of the COVID-19 vaccine.

As for the number of *against* and *in favor* tweets, it can be observed that they have oscillated during the analyzed period. Based on Figure 2 it can be observed that between November 9 and December 1 the number of *against* tweets has kept a constant trend, with a few “spikes” on November 9, November 16 and November 23. In all of these days, the news released in the media were speaking about the efficiency of COVID-19 vaccines in clinical trials: for Pfizer and BioNTech on November 9 (event E1), for Moderna on November 16 (E4) and for Oxford AstraZeneca on November 23 (E7). Two major turning points for increase in the number of *against* tweets have been represented by December 2 and December 8, these being the days in which UK has authorized the Pfizer BioNTech COVID-19 vaccine (E10, 6242 *against* tweets) and the day in which the COVID-19 vaccination started in the UK (E12, 8429 *against* tweets).

Considering the evolution of the graphic containing the cleaned tweets from all the three categories, it can be observed that the number of *against* tweets follows on a

smaller scale the evolution of the number of *neutral* tweets (the curve of the *against* tweets being more flattened than in the case of the *neutral* tweets), while the *in favor* tweets follow more precisely the trend imposed by the number of *neutral* tweets (Figure 2; Figure 7 and Figure 8). As a result, for the *in favor* tweets one can observe an increase in most of the major events cases presented above. Even more, in the events announcing the effectiveness of the COVID-19 vaccines from different companies (E1, E4, E5 and E7) the *in favor* tweets have overpassed the number of *against* tweets. Even after the vaccine authorization in UK, the situation has not changed and the number of *in favor* tweets overpassed daily the number of *against* tweets (with approximately, on average, 2050 tweets per day).

2) ALL TWEETS STANCE ANALYSIS

As the difference, in the number of tweets, between the *in favor* and *against* stances in the cleaned dataset seem to have close values during the analyzed period, a stance analysis considering all tweets dataset has been performed.

In the study conducted on vaccination in Italian tweets, D'Andrea et al. [5] considered that one should analyze the whole tweets dataset (including retweets) as, some of the users who retweet a certain opinion or piece of information, generally believe in it and, instead of writing their own words to a particular situation, they might decide instead to share the information. As a result, we have run the stance analysis over the entire tweet-dataset and the results are presented in Figure 3.

As it can be observed from Figure 3, on November 9, when Pfizer and BioNTech announced their vaccine effectiveness, the number of retweets has been only slightly different from the ones of tweets (a difference of 497 tweets). On November 10, the number of cleaned tweets has been half compared to November 9, while the total number of tweets doubled, showing a high increase in the number of retweets. As the events marking November 10 were mostly referring to

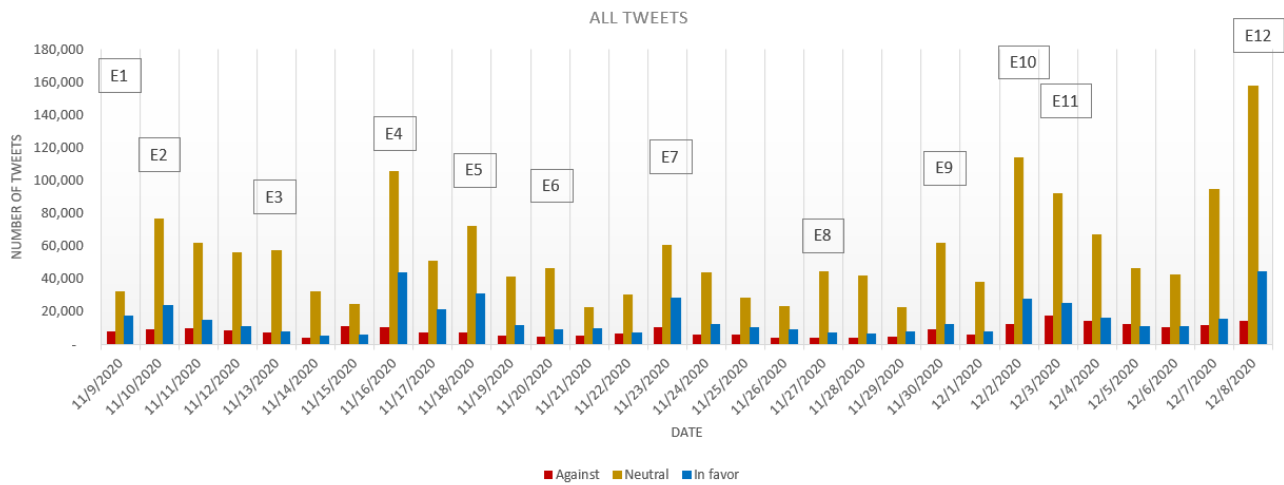


FIGURE 3. Evolution of all tweets stance.

the economic impact of a possible COVID-19 vaccine, such as the rose of oil futures and the announcement of a growth in stock market, in general, an increase in the *in favor* tweets over the *against* tweets can be observed (which has not been observed in the cleaned tweets dataset).

Even in this case, one can notice that the evolution of the number of *in favor* tweets resembles more closely to the evolution of the *neutral* tweets. The increase in the number of tweets marked as *in favor* is better visible in the case of the occurrence of the events mentioned above E1-E12, more precisely in the cases of E2, E4, E5, E7, E10 and E12 (Figure 9), than in the other days of the analyzed period. For the *against* tweets, except for the increase observed in the period following E10 (Figure 10), the evolution is almost constant, recording an average number of *against* tweets of approximately 6826 tweets/day. After E10, the number of daily *against* tweets recorded an increase of 95.28%.

Comparing the number of tweets recorded in the three categories for the period between December 2 – December 8 (E10-E12) with the period between November 9 – December 1 (E1-E9), it can be observed that the higher relative increase has been recorded in the *against* tweets category (95.28%), followed by *neutral* (87.86%) and *in favor* (54.86%). The smaller difference noticed between the number of tweets in the *against* category compared to the *in favor* category can be attributed to the fact that starting from December 2 (E10) the potential of having a vaccine was no longer a “dream” but it became “reality”, which might have “activated” the anti-vaccination community.

3) CONTEXT RELATED EVENT COMPARISON

For better understanding the opinion polarity in connection with a given event, we have considered in the following, three major events recorded in this month: first announcement of a possible effective vaccine (E1), first authorization of a

vaccine (E10) and first vaccination (E12), all of them creating spikes in the number of tweets.

As a result, it has been decided to aggregate the opinions expressed in the days corresponding to the three events for both the cleaned and for the entire data set. The results have been summarized in Figure 4.

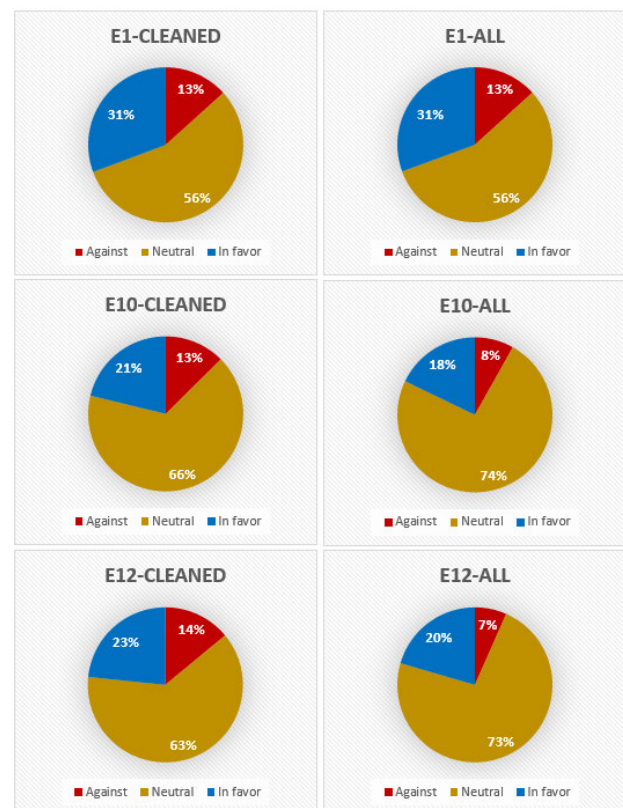


FIGURE 4. Context related event comparison (for E1, E10, E12).

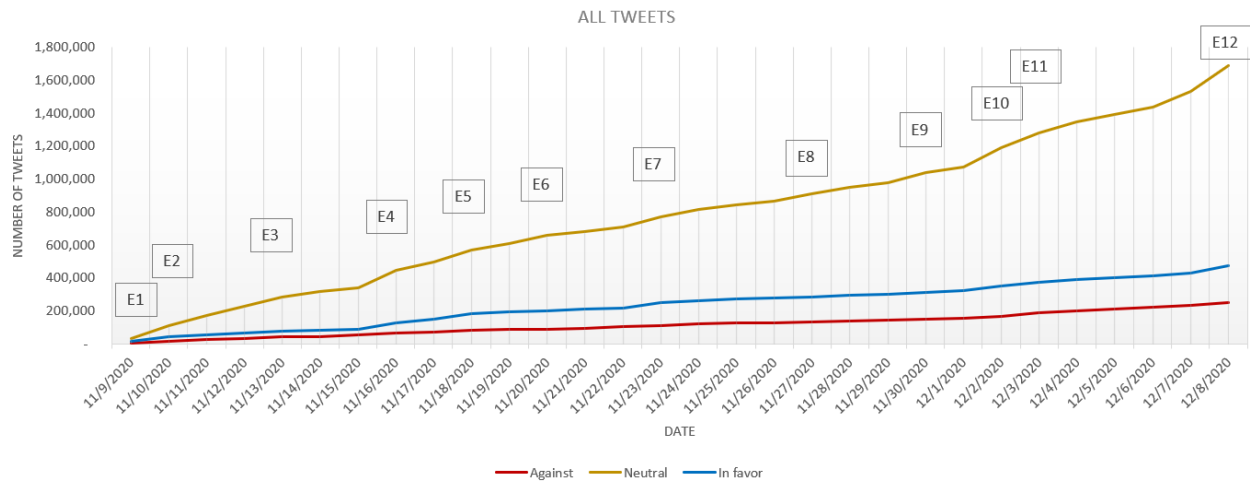


FIGURE 5. Cumulative stance analysis evolution.

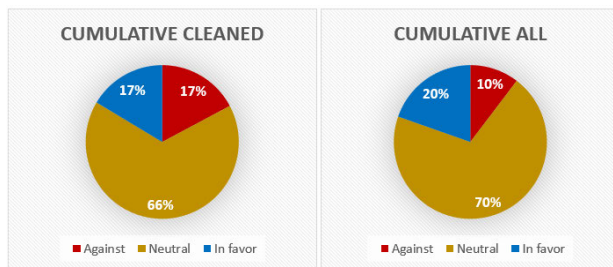


FIGURE 6. Cumulative stance comparison.

A first observation is related to the fact that the stance is overall *neutral* for the considered events. Particularly, in terms of relative distribution, one can note that that percentage of the *neutral* tweets in total number of tweets has recorded a slight increase of 17% (from 56% for E1 to 73% for E12) when all the tweets are considered and an increase of 7% on cleaned tweets (from 56% for E1 to 63% for E12) – please see Figure 4.

A higher percentage variation, in relative terms, can be observed for the *in favor* tweets: on the entire dataset the percentage dropped from 31% to 20%, while in absolute value, the number of *in favor* tweets almost doubled from 17 526 tweets for E1 to 44 447 tweets for E12 (with 27 487 tweets for E10).

A decrease in the percentage of tweets from the entire sample can be also observed in the case of *against* tweets, even though, in this case, the decrease is of only 6% (from 13% to 7%). Considering the cleaned tweets, the percentage of the *against* tweets has faced an increase of 1% (between E1 and E10-E12). Even in this case, the absolute number of *against* tweets on all dataset increased from 7604 tweets on E1 to 12 541 on E10 and to 14 359 on E12.

Another observation can be made in connection to E1 and E10: it can be observed that in the case of the *against* tweets, the increasement of the number of these tweets happened mostly in the following days after the events occurred, not

being so visible in the day of the event. This observation is in line with the study conducted by D’Andrea *et al.* [5], in which the authors have shown that sometimes the effect of an event is immediately visible, while in some other cases, it might need some hours / a day in order to be visible in the tweets. A possible explanation for this lag in response might be related to the fact that the users posting *against* tweets might have needed some time in order to look for information related to the event prior to tweeting.

4) CUMULATIVE STANCE ANALYSIS

As expected, the predominant stance of the cumulative set is *neutral* both in the entire set (Figure 5) and in the cleaned set.

The percentage of the *against* and *in favor* reaches the same value in the case of cleaned tweets, even though in absolute value, there can be noticed a difference in favor of the *against* tweets (Figure 6). On the entire dataset, the *in favor* tweets have a 10% difference compared to the *against* tweets (Figure 6). As the difference between the *in favor* and *against* tweets is not as visible as expected (Figure 6) and a global vaccination campaign is expected, the involved agencies and governments should try to provide more information regarding the vaccination process, its advantages and its presumed disadvantages, offering to the general public all the needed instruments and information for increasing their trust in the decisions taken at a macro-scale, with impact on everybody’s life.

VII. LIMITATIONS OF THE STUDY

A potential limitation of the current study is represented by the classification algorithms selected in the paper. As the Natural Language Processing field is in continuous development, better algorithms could be developed over time providing an improved classification performance. Another limitation is related to the selected dataset, which only includes tweets extracted between November 9, 2020 and December 8, 2020, written in English. This limitation opens the path towards

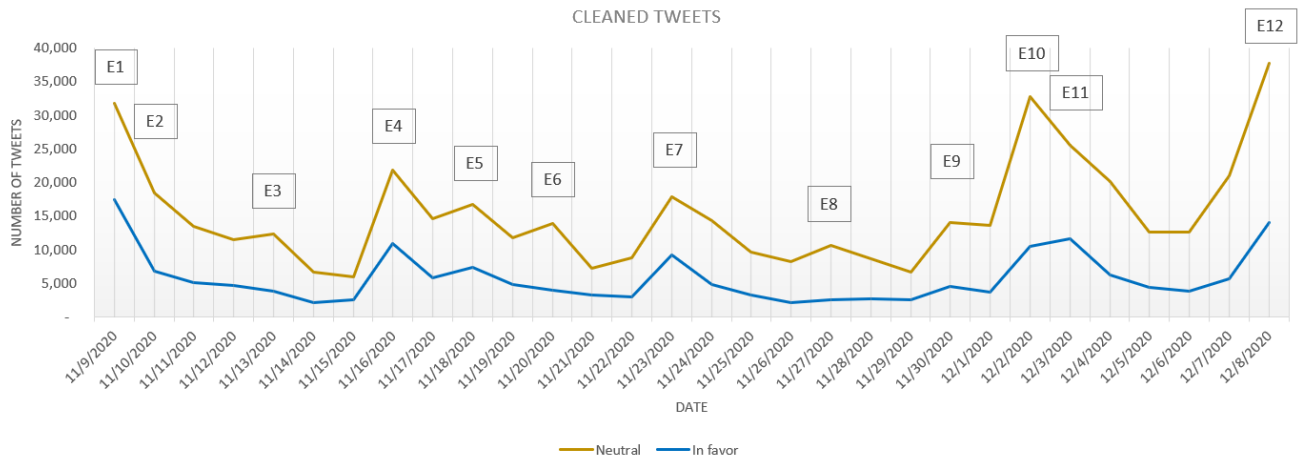


FIGURE 7. Evolution of *neutral* and *in favor* cleaned tweets.

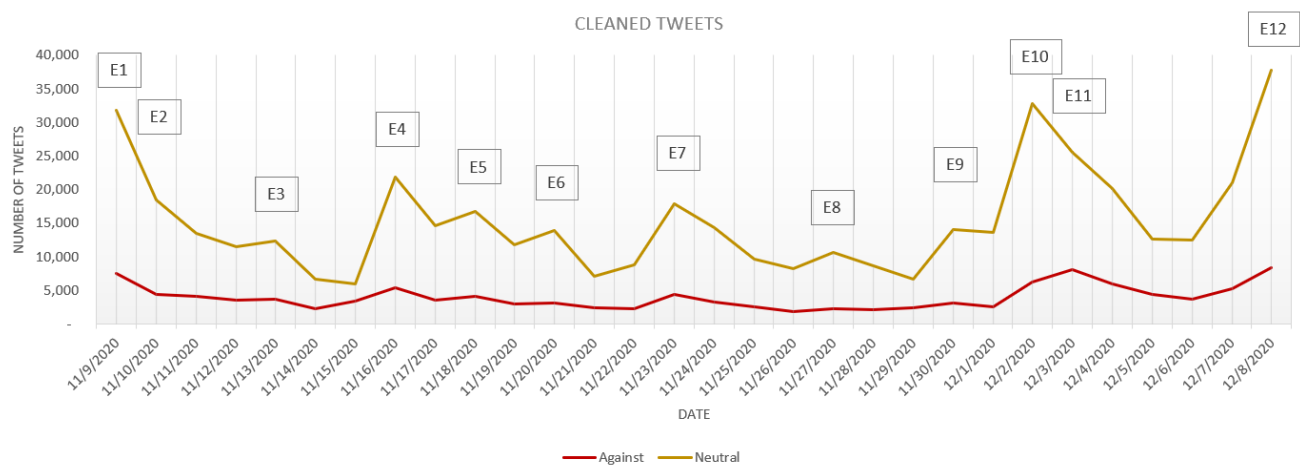


FIGURE 8. Evolution of *neutral* and *against* cleaned tweets.

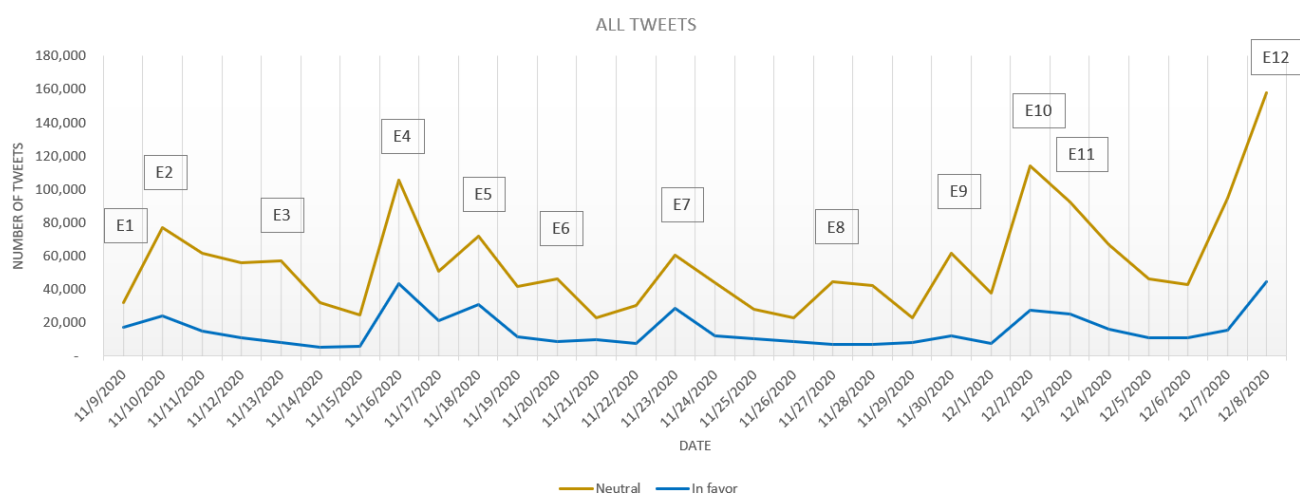


FIGURE 9. Evolution of *neutral* and *in favor* for all tweets.

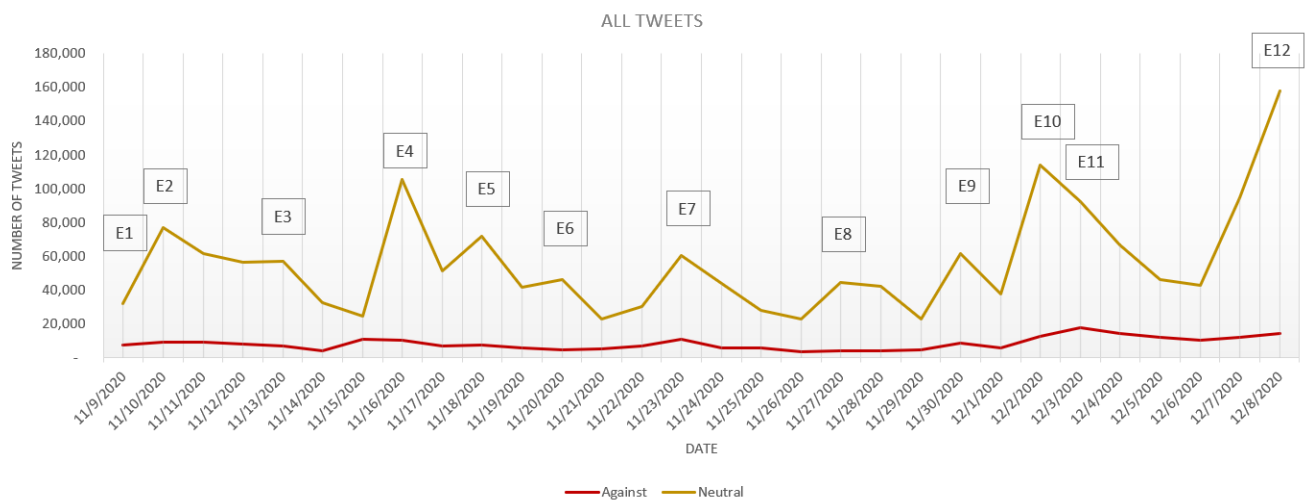


FIGURE 10. Evolution of *neutral* and *against* for all tweets.

other possible extensions, which might include, but not limited to analyzing the tweets written in other languages or from specific geographical areas, which could be identified using the associated GPS coordinates. Additionally, a different period of time could be considered due to the vaccination process dynamics worldwide.

VIII. CONCLUSION

In the current paper, the one-month period passed between the first announcement of a coronavirus vaccine and the first actual vaccination process started outside the limited clinical trials has been analyzed using machine learning-based stance detection. Multiple classical machine learning and deep learning algorithms have been compared and the best performing classifier has been chosen based on four performance metrics.

The proposed approach has classified the tweets into three main classes, namely *in favor*, *against* and *neutral* regarding COVID-19 vaccination, employing BERT with an accuracy of 78.94%.

The aim of the paper has been to monitor the evolution of the stance towards COVID-19 vaccination from tweets, by matching the number of Twitter messages with the main events reported by the media in the analyzed period.

The main stance was *neutral* at both a daily level and for the entire period, on either the cleaned dataset or on the complete dataset (dataset including all the tweets). In terms of *neutral* tweets' percentage recorded at the beginning of the period, November 9, versus the end of the analyzed period, December 8, it has been observed that the percentage has increased with 17% on the complete dataset. The evolution of the *in favor* tweets has been characterized by a series of spikes, closely following the evolution of the *neutral* tweets, but at a reduced scale. For both the *neutral* and *in favor* tweets it has been observed that some of the events in media

have entrained a series of spikes, which are not encountered in the case of *against* tweets, where the major spike has been represented by the authorization in the UK of the Pfizer BioNTech COVID-19 vaccine.

Even more, it has been observed that in the case of the *against* tweets there is sometimes a lag between the day in which a certain event has occurred and the change in the number of *against* tweets. The existence of such a lag in tweets posting has also been mentioned by D'Andrea et al. [5] in a paper regarding vaccination in Italy.

The correspondence between the information in the tweets and the events in the media has been confirmed by analyzing the n-grams, underlining even more the fact that the tweets reflect the hot topics in the society at large.

The early detection of an opinion shift might be highly useful in the context in which many countries from all around the world are planning to start the COVID-19 vaccination process, as it would allow governmental decision makers to promote actions aimed at limiting the distribution of fake news and increasing the general public's confidence towards vaccination. The analysis can be performed on a daily basis, in order to have a real-time overview of the stance evolution.

Possible future research directions include the development of better performing stance classification algorithms, as well as extending the analyzed period, especially given the fact that the vaccination process is expected to take a relatively long period of time.

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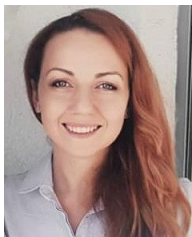


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Les hauts magistrats et « l'entreprise Justice »

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Enfin, les dispositifs de mobilisation en ligne, notamment le pétitionnement, constituent une dernière thématique de recherche.

Résumé

Fondée sur l'étude qualitative de 18 discours prononcés par de hauts magistrats de la Cour de cassation lors des audiences solennelles de rentrée entre 1980 et 2020, cette étude souhaite montrer que faire cohabiter en discours la tradition et les nouveautés induites par la pénétration d'une logique managériale au sein de cette Cour relève d'un *ethos* de continuité et traduit un positionnement professionnel de ses chefs.

Les hauts magistrats et « l'entreprise Justice »

(version non définitive en raison des droits d'auteur)



Les hauts magistrats et « l'entreprise Justice »¹

La Cour de cassation occupe une place singulière dans les institutions françaises. Ses juges ne rejettent pas une affaire, ils vérifient les bonnes application et interprétation de la loi par les magistrats des deux niveaux de juridiction (tribunal et cour d'appel). A l'issue de ses examens, elle produit ou non une jurisprudence. En cela, elle est un organe normatif (elle unifie l'interprétation de la loi générale, homogénéisant ainsi son application)². Selon Alain Bancaud, les hauts magistrats de la Cour de cassation incarnent une institution caractérisée par la tradition, l'unité et la continuité. La Cour, par son corps (les magistrats), ses rituels, ses pratiques, ses décisions remplit « la mission d'assumer une stabilité juridique » (Bancaud, 1989, p.36). Cette stabilité, assurée entre autres par le respect du droit existant, permet à la Cour de s'autonomiser par rapport aux alternances et contingences politiques (Ibid.).

Nous souhaitons étudier la manière dont ce que nous appellerons un éthos de continuité se construit en discours lors des audiences solennelles de rentrée de la Cour entre 1980 et 2020. L'éthos se définit comme « l'image que l'orateur construit de sa propre personne pour assurer sa crédibilité » (Amossy, 2014, p.13). Ce terrain d'étude se justifie à deux égards.

D'une part, les audiences solennelles de rentrée sont des rituels traditionnels et publics. La Cour de cassation s'y plie depuis 1826 (Farcy, 1998, p.31). La tenue du discours, sa teneur et la qualité requise de l'orateur ont connu des vicissitudes au cours des siècles mais à partir de 1974 un décret impose au discours de contenir à minima un bilan de l'activité de la juridiction (Ibid., p.40). Le reste peut concerner : « un sujet d'actualité ou [sur] un sujet d'intérêt juridique ou judiciaire. » (Article R111-2)³ Le discours peut maintenant être tenu par le premier président et / ou par le procureur général. Il se construit donc en fonction de règles législatives mais aussi des usages et des attendus du public. Ce dernier est composé de magistrats (souvent des responsables de hautes juridictions), de journalistes, de politiques, de personnalités politiques ou judiciaires étrangères parfois du ministre de la Justice, du président du Sénat ou du président de la République.

D'autre part, l'activité des juridictions, soit le cœur du discours de rentrée requis par la loi, et leur organisation sont l'objet d'une attention de la part des gouvernements successifs depuis les années 1980 (Vigour, 2008). Les réformes, dites de modernisation de la justice, instaurent progressivement une rationalité de type managérial dans la gestion des activités des Cours et tribunaux (Vigour, 2006, p.428 ; Willemez, 2010, p.18). L'institution judiciaire est amenée à se penser comme une organisation guidée par des principes tels que la productivité, la rationalisation budgétaire, l'efficacité (Bezès, 2012), la qualité et l'évaluation (Vigour, 2006). Cela induit des réagencements affectant profondément le fonctionnement des juridictions (ibid., p.430). Le budget de l'institution entre de plus dans le cadre de la loi organique relative

¹ L'expression a d'abord été utilisée par Robert Badinter quand il était ministre de la Justice et a été reprise par Simone Rozès dans un des textes de notre corpus entre autres.

² voir Cour de cassation (sous la direction du Service de documentation, des études et du rapport), *Le rôle normatif de la Cour de cassation, Etude annuelle 2018*, La Documentation française, décembre 2018, 344 p.

³ Code de l'organisation judiciaire, en vigueur au 1^{er} janvier 2020. [En ligne] https://www.legifrance.gouv.fr/affichCodeArticle.do?sessionId=79A16A0E90752DD0EDD4BA954B4223AE+plgf27s_2?idArticle=LEGIARTI000039066938&cidTexte=LEGITEXT000006071164&categorieLien=id&dateTexte=, consulté le 8 juin 2020



aux lois de finances (LOLF) votée en 2001. Celle-ci, substituant « une logique de performance et de résultats à une logique de moyens » (Marshall, 2008, p.121), contraint la justice à traduire, à partir de 2006, son action en termes gestionnaires. Le contexte politique choisi pour cette étude correspond donc à une période de transition susceptible de déstabiliser l'institution judiciaire et ce faisant la Cour de cassation. Par ailleurs, les chefs des juridictions sont des acteurs de la mise en œuvre de ces réformes (Jean, 2008, p.11-12 ; Vigour, 2006, p.432). Les orateurs doivent donc convaincre qu'ils sont, dans notre cas, à la fois les garants de la continuité et de l'unité du droit et les garants de la modernisation de la Cour. L'image élaborée en discours, si elle doit être appropriée pour réussir, se charge ainsi d'une dimension argumentative (Amossy, 2014, p.22, 23).

Dans ce cadre, notre hypothèse se fonde sur une extension des propositions de A. B. : si dans ses écrits la continuité concerne essentiellement le droit (Bancaud, 1987, 1989), nous y associons l'organisation concrète du travail propre à son émergence. Ainsi nous souhaitons montrer que faire cohabiter en discours la tradition et les nouveautés induites par la pénétration d'une logique managériale au sein de la Cour de cassation relève de l'éthos de continuité et traduit un positionnement professionnel de ses chefs. L'article est élaboré en trois temps. Tout d'abord, nous verrons comment l'éthos de la continuité passe par un ancrage dans la tradition. Celle-ci concerne aussi bien le dit (les thèmes abordés) que le dire des hauts magistrats (la manière dont ils s'expriment). Ensuite nous étudierons la façon dont ces derniers prennent en charge en discours l'introduction d'une rationalité managériale au sein de leur Cour. Enfin, nous repérerons des éléments liant ces deux pôles, propres à manifester la continuité et l'unité des pratiques et du corps.

Pour mener notre analyse, nous avons choisi d'étudier les discours des premiers présidents et procureurs généraux des années 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015 et 2020⁴. Nous avons gardé les discours des deux têtes de la Cour pour deux raisons. Premièrement, si historiquement le discours d'audience de rentrée fait partie des prérogatives du procureur général, selon les archives disponibles sur le site de la Cour, Le premier président s'exprime systématiquement depuis 1967. Deuxièmement, nous n'avons pas constaté de division du travail systématique entre les deux types d'orateur. Les rôles bien différents du premier président (il dirige les magistrats du siège, ceux qui jugent les délibérés et établissent les jurisprudences, et est le responsable de la juridiction) et du procureur général (il est responsable du parquet qui a pour tâche d'éclairer les décisions des juges) ne traduisent pas en discours. Leur propos sont complémentaires mais selon des modalités qui sont propres à chaque binôme. Concernant les bornes du corpus, les années 1980 marquent, comme nous l'avons indiqué, les débuts de la rationalisation et de la gestion managériales des activités de la justice. Nous avons choisi d'aller jusqu'en 2020 car ce sont les discours les plus récents. Concernant les dates retenues. Nous avons tenté d'objectiver le choix des années en adoptant une périodicité régulière, aboutissant à un nombre raisonnable de discours (18). En effet, ceux-ci sont longs (3198 mots en moyenne) et l'étude non outillée : nous avons procédé manuellement pour chaque discours d'un côté à une analyse de contenu par catégorisation et repérage des champs sémantiques associés (par exemple : « organisation du travail », « références à l'histoire », « Europe », « quantification de l'activité »). Les catégories ont été

⁴ Tous les discours prononcés aux audiences de rentrée de la Cour de cassation sont disponibles sur le site de la Cour. Un tableau récapitulatif du corpus se trouve en fin d'article.



élaborées de façon inductives. De l'autre nous avons pointé des observables relevant de l'analyse de discours tels que les citations, les phrases complexes, le méta-discours.

L'ancrage du discours dans la tradition

La Cour de cassation est une institution traditionnelle. Elle entretient des liens forts avec le passé. D'un point de vue juridique, c'est dans le droit existant, produit par des pairs souvent disparus, qu'elle trouve le cadre à partir duquel elle produit la jurisprudence. S'appuyer sur le passé est donc la garantie pour cette Cour de la stabilité du droit, régulateur de l'ensemble de la société (Bancaud, 1989). Elle est en quelques sortes nécessairement traditionnelle. En nous appuyant sur une étude de Jean-Claude Farcy (1998) portant sur plus de 3600 discours de rentrée aux audiences solennelles des cours d'appel aux XIX^e et XX^e siècles, nous avons pu repérer dans notre corpus des éléments thématiques et discursifs propres à ces cérémonies. L'inscription de leur discours dans un canevas et des formes qui leur préexistent permet aux chefs de juridiction de renforcer la communauté –discursive – des magistrats et d'affirmer qu'ils assurent une continuité avec le passé.

Le contenu des audiences solennelles

Tous les discours ou presque respectent un canevas comprenant les remerciements aux personnalités remarquables présentes dans le public et les politesses convenues, le bilan de l'activité et son organisation, quelques revendications adressées au politique, le développement d'un thème donnant l'occasion à l'orateur d'exposer des idées sur la justice et ses rapports à la société et de façon plus occasionnelle une nécrologie élogieuse. Ces éléments sont communs aux discours de notre corpus et à ceux étudiés par J.-C. F. (p.43 et 46). Les magistrats se coulent ainsi dans une tradition, dans un déjà-là du discours. Ils s'expriment en tant que responsables d'une juridiction, descendants d'une lignée de magistrats. Les sujets développés par les chefs de Cour, identifiés lors de l'analyse de contenu de notre corpus, sont l'engorgement de la Cour ; l'histoire du droit social ; la fonction, les devoirs et l'image du juge et ses évolutions ; la construction européenne et ses conséquences pour la Cour ; le juge d'instruction et sa possible disparition ; les nouvelles technologies de l'information et de la communication ; les rapports de la Cour aux Français ; les médias ; le rôle du parquet de la Cour et de la Cour en général. Certains discours s'éloignent du monothématisme et articulent plusieurs entrées.

En outre, J.-C. F. nous apprend que la magistrature affectionne les sujets historiques (1998, p.211). L'histoire, par le rappel de la grandeur de l'institution et des principes de la justice, a vocation à « fortifie[r] l'esprit de corps des magistrats » (Ibid., p.245). C'est dans ce contexte que le culte des ancêtres illustres prend place. Cela est remarquable par les nombreuses citations et références à d'anciens magistrats ou juristes. Portallès, l'un des rédacteurs du Code Civil, est celui qui est le plus cité. Un lien est ainsi tissé entre les magistrats du passé et ceux du présent, rassemblant le corps autour de figures tutélaires. Les nécrologies, dont la présence est aléatoire dans notre corpus, nourrissent également ce culte en faisant l'éloge des magistrats perdus. Cet aspect des discours est renforcé par le lieu de l'énonciation ; lieu ici considéré comme « un espace de production de signes » (Boutet, Gardin et Lacoste, 1995, p.20) hautement symbolique. Les audiences de rentrée se tiennent en effet dans la première chambre civile de la Cour de cassation, située au cœur de l'Île de la cité, à Paris. Aux quatre



coins du plafond de la pièce sont disposés les portraits de quatre figures historiques ayant marqué le droit français : Justinien, Charlemagne, Saint Louis et Napoléon Bonaparte. La cérémonie se déroule physiquement sous leur autorité.

Le parler traditionnel des audiences solennelles

La prise en charge des éléments du discours s'ancre dans des manières de dire repérables. Elles peuvent être caractérisées de trois manières : la technicité, la complexité syntaxique et le lyrisme.

Concernant la technicité, elle établit l'expertise des orateurs et l'unité du corps de la magistrature. L'extrait reproduit ci-dessous en atteste :

Une lecture sans doute trop rapide de l'article 6 du traité sur l'Union Européenne (TUE) selon lequel l'Union adhère à la convention de sauvegarde avait peut-être fait oublier que le protocole n° 8 précise que le traité d'adhésion doit, je cite, « refléter la nécessité de préserver les caractéristiques spécifiques de l'Union et du droit de l'Union ». La Cour de Justice de l'Union a donc constaté que l'accord d'adhésion n'a prévu aucune disposition pour assurer la coordination entre les niveaux de protection conférés respectivement par la Charte des droits fondamentaux de l'Union et par la Convention de sauvegarde.
(Marin, en 2015)

La technicité du propos est accentuée par la référence aux sources et à la citation de textes. En cela, le haut magistrat affirme son « rôle de *lector* » (Bourdieu, 1986, p.6). Il se présente comme l'interprète de textes à partir desquels il apprécie des situations. Pour aller plus loin, l'interprétation est le cœur de son activité puisqu'il cherche à faire émerger le droit (la jurisprudence) du droit déjà là (les lois et les précédents) (Bancaud, 1989, p.31). Faire avancer ainsi son propos est une caractéristique du parler judiciaire donné à voir dans les discours. Marin active en cela à la fois une pratique langagière propre à son groupe professionnel et une façon de concevoir son rôle dans l'élaboration du droit.

Mais les références aux textes juridiques sont également la manifestation d'un « culte du texte » (Bourdieu, 1986, p.18), de la loi. Elles sont la marque d'une « loyauté républicaine » (Bancaud, 1987, p.378). Le lieu de cérémonie prolonge cet hommage : au centre du plafond de la salle, s'étend une peinture de Paul Baudry, la *Glorification de la loi*. Un écho s'opère alors entre le lieu et le discours. Nous y voyons une invitation à reconnaître la prééminence de l'autorité législative sur toute autre.

Le dernier élément technique renvoie à la lexie du procès. Nous trouvons ainsi régulièrement l'expression « l'audience est levée », le mot « réquisition », ou encore – moins souvent – des passages de clôture d'audience dont Lamanda, en 2010, donne un exemple : « La Cour, / Constate qu'il a été satisfait aux prescriptions du code de l'organisation judiciaire et dit que du tout il sera dressé un procès-verbal, versé au rang des minutes du greffe. » L'audience solennelle prend alors les atours d'une audience de procès. La disposition de la salle qui rappelle le procès, le protocole et l'habit revêtu par les magistrats renforcent cette dimension langagière des discours.

Concernant la complexité, les hauts magistrats affectionnent particulièrement les tournures indirectes, l'enchevêtrement des propositions ou les incises comme en atteste ce passage :

Celui-ci [bureau de l'Association des Hautes juridictions de cassation francophones] a décidé, à la demande de la Cour de cassation française présentée en liaison avec les Nations Unies, dont je salue la présence à cette audience du directeur exécutif du Comité contre le terrorisme, M. Jean-Paul Laborde, de mettre en place un programme de rapprochement des jurisprudences des Cours suprêmes francophones en matière de lutte



contre le terrorisme, car l'action de la Justice en ce domaine, comme celle de toutes les autres institutions au service de l'humanité, ne peut être qu'internationale. (Louvel en 2015)

La technicité et l'aspect démonstratif des audiences de rentrée n'empêchent pour autant pas quelques passages lyriques dont Draï, en 1995, donne un exemple. Il s'adresse aux membres du conseil supérieur de la magistrature présents dans la salle :

Vous montrez ainsi votre attachement à l'institution judiciaire et au-delà même de la Cour de cassation, tout l'intérêt que vous portez aux juges de notre pays, ces juges qui, de crise en crise, avancent ou tentent d'avancer sur le chemin difficile de la vérité, avec les moyens sommaires qui sont souvent les leurs et dans l'éblouissement des projecteurs d'une actualité, souvent cruelle et toujours fugace.

L'éloquence s'enrichit par ailleurs d'un goût pour la tradition dont les belles lettres (Farcy, 1998, p.64). Les références littéraires et philosophiques dont sont ornés certains discours en témoignent. Celui de Burgelin (2000) évoque ainsi tour à tour Malraux, Baudelaire, un conte de Perrault, Muray, Alain et Montesquieu. Les chefs de Cour réaffirment en-cela leur appartenance à une culture professionnelle définie en partie par ses manières de dire.

Le management s'invite à la Cour

Les éléments rappelant l'ancienneté et le prestige de l'institution sont peu à peu étoffés par ceux relatifs au management. Jean-François Dortier (2004, p.520) définit ainsi les fonctions du travail managérial :

La stratégie [...] / la gestion : comptabilité, gestion des stocks, salaires, administration, informatique, locaux ; / l'organisation du travail : répartition des tâches, circulation de l'information, définition des responsabilités ; / le marketing [...] ; / les ressources humaines : communication interne, motivation, rémunération, recrutement, formation du personnel.

Au-delà de la quantification de l'activité, la catégorie du travail managérial menée par les chefs de la Cour de cassation visible au sein des discours relève majoritairement de l'organisation du travail. Nous étudions à présent la manière dont la rhétorique managériale pèse sur les discours de rentrée. Pour cela, nous nous attachons d'abord à repérer le champ sémantique du management, ensuite à voir comment les magistrats se le sont appropriés, et enfin à observer les changements syntaxiques qu'il semble induire.

L'activité et son organisation

La justice est un des premiers objets sur lequel s'est construit « l'appareil statistique de l'Etat français » (Vauchez, 2008, p.113) Les chiffres servaient notamment à figurer au politique l'état moral du pays. Ils ont également servi et servent encore d'argument pour demander davantage de moyens. Cependant, dans les années 1980 et surtout 90 (Idem.), la quantification de l'activité devient une préoccupation majeure en ce qu'elle permet de l'objectiver, de la mesurer et de la comparer. La production de chiffres sert alors à évaluer l'institution elle-même (son coût, sa productivité etc.). Ils portent pour le cas de la Cour de cassation essentiellement sur le nombre de pourvois traités par un certain nombre de magistrats et le



délai de leur traitement. Pour autant, la présence de chiffre n'est pas systématique dans les discours étudiés. Ils sont parfois rejetés comme le fait Bellet en 1980 : « Nous ne voudrions pas trop vous attrister, monsieur le ministre, dès les premiers jours de l'année, par des chiffres et des statistiques, et mêler aux vœux traditionnels des complaints fastidieuses. », parfois absents (en 2000, 2005, 2010, 2015 par au moins un des deux intervenants), parfois encore externalisés dans un « rapport annuel »⁵ remis à l'auditoire que certains discours mentionnent à partir de 1980. Les discours qui contiennent des données chiffrées, quant à eux, les rattachent au champ lexical de la productivité. Nous pouvons alors lire les termes ou syntagmes : *production, force productive, capacité de traitement, stock, rendement, afflux, importance quantitative, processus de maîtrise des flux d'affaires, taux, efficacité*, etc.

En 2005, Canivet franchit un pas en évoquant des « indicateurs », « des repères objectifs de qualité ». Ces derniers renvoient à des données chiffrées. Il révèle alors la mise en forme de l'activité de la Cour dans les canons de la LOLF. En effet, les « indicateurs de performances » sont les éléments sur lesquels se fondent l'évaluation des missions de l'Etat, dont la justice fait partie, définies par la LOLF⁶. La langue de la réforme d'Etat a infiltré celle du magistrat.

La manière dont sont organisées les activités de la Cour est une thématique presque systématique lors des audiences de rentrée. Notre corpus porte ainsi les traces de la matrice cognitive (Ravinet, 2011) propre au management. Bézio, en 1990, mentionne d'ailleurs la création dans ces mêmes années d'une « Commission organisation et méthode ». Pour la Cour de cassation, l'organisation des activités correspond à la description de tout ce qui est mis en place pour que les magistrats soient plus efficaces dans le traitement des pourvois. Il peut s'agir d'éléments techniques comme le recours aux technologies de l'information et de la communication permettant la dématérialisation et l'accélération des procédures. Cela touche les méthodes de travail comme la mise en place de formules d'arrêt types, de procédures allégées ou la répartition et le tri sélectif des pourvois (avec spécialisation possible des magistrats). Mais cela concerne également les tâches assignées à chacun ou la répartition du travail comme l'évolution du rôle du greffe et du service de documentation ou l'organisation des chambres en sections. Peu à peu, les discours font référence à de nouvelles manières de penser le travail et les termes *projet, mission, objectif* apparaissent. Tout doit être mis en œuvre pour que la Cour soit « comme on peut l'attendre d'une grande institution de ce XX^e siècle. » (Nadal en 2005). L'exposé de ces réorganisations atteste de la bonne volonté de la Cour, de son loyalisme et de son « sens du compromis avec l'époque » (Bancaud, 1989, p.37). La Cour, pour assurer sa mission, doit en quelques sortes absorber et faire sienne les évolutions et les demandes politiques.

De la distance à l'appropriation des mots du management

Dans notre corpus, faire tenir ensemble le parler judiciaire et le parler managérial est progressif. C'est le fruit d'une appropriation de celui-ci par les chefs de juridiction, dont les

⁵ Ce document est développé à partir de 1984 grâce à la création d'une commission du rapport et des études au sein de la Cour.

⁶ *Guide LOLF 2012*, en ligne https://www.performance-publique.budget.gouv.fr/sites/performance-publique/files/files/documents/ressources_documentaires/publication_s/guide_pratique_lolf2012/guidelolf2012_1.pdf consulté le 12 mai 2020



discours portent la trace. Nous verrons la manière dont la distance a été marquée puis s'est estompée.

Tout d'abord, la manière la plus distanciée de faire une place à une rhétorique relative à la gestion rationalisée de l'activité est se référer de façon critique à ce qu'est devenu l'objet imposé du rituel. L'auditoire assiste à deux représentations : l'audience solennelle de rentrée et ce qu'on lui demande de devenir. L'orateur est alors dans un entre-deux inconfortable que son discours constitue en même temps qu'il le manifeste. Voilà comment Schmelck commence, en 1980 :

Le genre que d'Aguesseau illustra [...] est passé de mode. / Aujourd'hui, un procureur général aurait scrupule à entretenir son auditoire de savantes dissertations sur la fonction morale de la justice, les devoirs des magistrats et les grands sentiments qui doivent les animer. Notre époque n'a plus le goût des digressions philosophiques et des développements oratoires. / De nos jours, la pensée se veut « utile » et le style « fonctionnel ». Un discours de rentrée ressemble désormais, de plus en plus, au froid rapport du commissaire aux comptes d'une société, qui se doit d'exposer à l'autorité qualifiée, la situation de l'entreprise auprès de laquelle il est établi, d'analyser ses activités et de révéler ses difficultés de fonctionnement. / Mon exposé n'aura pas d'autre objet.

Cette introduction justifie son propos. Le bilan qu'il dresse et la manière de le faire ne sont donc pas le fruit de sa volonté mais sa réponse contrainte à l'époque dans laquelle il se trouve.

De façon plus légère, certains orateurs mettent en scène leur emploi des mots du management par des modalisations autonymiques (Maingueneau, 2016, p.169), renforçant ainsi leur étrangeté. Bellet, en 1980, veut « employer des mots à la mode » (concertation, dialogue), la même année Schmelck se demande « si j'ose m'exprimer ainsi » (production). Dans ces cas, la distance est formulée et explicite. Comme l'explique Dominique Maingueneau, le discours se dédouble : l'orateur « parle tout en commentant en même temps sa parole en train de se faire. » (p.169). Mais la distance peut également être indiquée typographiquement, avec des guillemets. Ces derniers font porter l'attention du lecteur (ou de l'auditoire par une inflexion de la voix) sur l'emploi du mot, en rejette la responsabilité et cherche à s'en dissocier (Ibid., p.172). Ils traduisent la volonté des chefs de Cour de marquer une distance entre eux et ce qu'ils sont en train de dire et de faire. Autrement dit, ils donnent à voir la « non-coïncidence » (Authier-Revuz, 1995 in Krieg, 1996) de leur discours avec eux-mêmes. En 1985, Arpaillange évoque ainsi « un « document de travail » » et dresse « « le bilan » des forces et des faiblesses ».

Sur ces trois premiers points, l'audience de Rozès en 1985 est remarquable : après avoir mis en scène son intervention, elle évoque la circulation de la rhétorique propre à la gestion de l'activité entre le monde économique, le ministre de la Justice de l'époque et la Cour de cassation et déclare son acceptation :

Nous utilisons déjà des mots qui appartiennent au monde économique - c'est-à-dire à notre monde contemporain. Pour mieux frapper l'imagination de vos auditeurs ou de vos lecteurs, vous avez, monsieur le garde des Sceaux, employé l'expression assez provocante de « l'entreprise Justice ». Nous acceptons ici le défi et déjà, depuis longtemps, nous n'hésitons pas entre nous à parler de « stock » de dossiers, de contentieux « de masse », d'« inflation » des pourvois, vocabulaire qui aurait frappé de stupeur nos anciens [...].

Comme pour ancrer le phénomène d'appropriation, elle emploie par deux fois, à la fin de son intervention, le terme *entreprise* en conservant la modalisation autonymique des guillemets mais sans le rattacher à la proposition ministérielle. Le discours apparaît alors comme le récit de la mise en conformité de la Cour avec une vision du travail inspirée de l'économie. Dans le



même sens, Alice Krieg-Planque rappelle, dans son commentaire de l'ouvrage de Jacqueline Authier-Revuz que si la modalisation autonymique est le signe de « l'hétérogénéité inhérente à la langue », elle est également une façon pour un locuteur de « représenter localement la maîtrise qu'il a de cette hétérogénéité » (1996, p.151). Les chefs de Cour montrent, par l'usage des guillemets, à la fois leur distance et la preuve de leur capacité à utiliser des mots relatifs à la rationalité managériale. Ces premières formes de distanciation s'essouffent dès les années 1990 ; le vocabulaire est rapidement intégré à l'exposé des activités de la Cour. Nous retrouvons les guillemets autour de l'expression « open data » en 2020 dans le discours de Arens, signe d'un renouveau de l'hétérogénéité lexicale.

Une nouvelle manière de dire, repérable particulièrement en 2020

La rhétorique managériale ne s'apprécie pas uniquement comme un lexique au sein duquel les producteurs de discours pourraient venir piocher. Elle opère un changement de perspective sur le travail mené et elle façonne la construction du dire. Dans notre corpus, cela se traduit par un changement dans la structuration du propos, l'émergence du pronom personnel « je » en tant que porteur de projet et une simplification syntaxique.

Tout d'abord, la structuration de la première partie du discours du procureur Molins suit la logique imposée par la LOLF. Autrement dit, il présente les actions mises en place, telles que des petits déjeuners thématiques, et les résultats de ses projets fondés sur la base d'objectifs qu'il s'était fixés. La manière de penser son travail aussi bien que celui de ses collègues est fondue dans les canons de la gestion. Ensuite, les deux chefs de Cour se positionnent comme les responsables des « chantiers » à mener. Molins a présenté antérieurement ses « ambitions » et son « projet ». La notion de projet charrie toutes les aspirations du néolibéralisme à faire porter par les individus la responsabilité du bien aller des entreprises, des administrations et d'eux-mêmes (Panico et Pouille, 2005). Chaque salarié, ou ici magistrat, devient un acteur porteur d'un projet qu'il a la charge de mener à bien. Un projet étant construit autour d'objectifs, il est aisé de l'évaluer et ce faisant d'évaluer son porteur. La présidente Arens s'inscrit également dans cette logique. Son discours est remarquable par l'émergence du pronom personnel « je » comme acteur individualisé de la conduite du changement :

je souhaite à la fois conduire, avec les magistrats de la Cour, des réformes au sein de la Cour de cassation, et accompagner les transformations nécessaires [...] je me suis engagée, [...] j'entends mener à bien [...] j'entends coordonner l'ensemble des travaux [...] j'entends conduire les réformes [...] Mon objectif [...].

Elle porte la volonté du changement et l'adaptation de la Cour de cassation à de nouvelles méthodes de travail. En outre, et c'est en lien étroit avec le point précédent, Arens s'affirme comme porteuse d'une vision systémique de l'institution judiciaire qu'elle veut défendre à travers la mise en place de réformes et de propositions. L'individu s'affirme sous la fonction. Il y a donc une individualisation et une responsabilisation de l'initiative du changement. Ces deux interventions font en quelques sortes entrer la Cour dans le management par projets.

Concernant la simplification syntaxique, J.-C. F. (1998, p.78) remarquait déjà qu'au cours du XIX^e siècle, le style des audiences solennelles évoluait corrélativement à leur changement d'objet : si la défense du régime ou la censure des magistrats s'exprimaient aisément via « une rhétorique imposante », les propositions concernant le fonctionnement de l'institution et les points de droit se disaient plus favorablement au style direct et simple. Pour ce qui nous concerne, nous observons à nouveau un mouvement de simplification du propos, notamment



dans la technicité du vocabulaire et les tournures de phrases. En fait, au début de la période, certains passages laissent imaginer le remplacement d'un mot traditionnel par un mot relevant de la rhétorique managériale ; sans que la structure du propos soit touchée. Cet extrait l'illustre (Schmelck en 1980) :

Le bilan, positif à certains égards, n'était guère réconfortant à d'autres. Il s'en dégageait, certes, qu'au prix d'un effort particulièrement soutenu, la « production » de la Cour - si j'ose m'exprimer ainsi - ne s'était pas ralentie, loin de là. En six ans, le volume des affaires jugées annuellement n'avait-il pas augmenté de plus de 40 % en matière civile, de même que d'une manière très sensible en matière pénale ?

La forme interrogative et indirecte de la dernière proposition est par exemple une structure syntaxique qui pour parler de l'activité se raréfie fortement ensuite. Nous repérons toujours des phrases longues aux structures complexes mais elles ont déserté la partie « bilan » des audiences de rentrée. Le discours de Arens se démarque largement sur ce point : on y constate sur l'ensemble de son intervention une sobriété syntaxique, un style direct, et un vocabulaire accessible à un plus grand nombre.

Des chefs de juridictions continuateurs

Si l'éthos de continuité construit par les chefs de la Cour de cassation s'observe par la cohabitation de thématiques et de formes discursives propres à la tradition et au management, elle se manifeste aussi dans l'établissement de quatre types de lien. Cela permet en outre au chef de Cour de susciter l'adhésion des différents groupes qui composent son auditoire. L'éthos ainsi construit les montre capables de garantir l'évolution de la Cour tout en lui assurant sa stabilité et son autorité.

Le premier établit des continuités temporelles au sein du fonctionnement et des préoccupations de la Cour. Autrement dit, les orateurs puisent dans l'histoire ou les fondements philosophiques et politiques de la Cour pour justifier certaines réformes. Schmelck, en 1980, rappelle à l'auditoire que l'augmentation de l'amende « encourue par le plaideur abusif » n'est pas « une fâcheuse innovation du législateur contemporain » mais qu'elle « remonte à un édit de 1331 ». La même année, Bellet préconise « le rajeunissement des méthodes [...] en retrouvant l'esprit des choses et en retournant aux sources. » Marin, en 2015, trace des allers-retours entre passé et présent quand il appelle la Cour à s'interroger sur « sa fonction de régulateur sociale » : il fait le rapprochement entre la place que la Cour peut occuper au niveau international et l'Ordonnance du 25 août 1539 par le devoir que la Cour a de rédiger clairement ses arrêts (la clarté de ses décisions serait alors un facteur de prestige international). Il parle ensuite de la « fonction à la fois originelle et nouvelle de la Cour ». Ce premier type de lien s'inscrit dans le culte ou « le respect du précédent » (Bancaud, 1989, p.35). En effet, une des spécificités de l'activité de la Cour est de montrer que ses décisions, la jurisprudence, étaient en fait contenues de façon non explicites dans le droit déjà existant. Ainsi, en formulant des nouveautés relatives à l'organisation du travail dans les termes de décisions ou méthodes anciennes les orateurs, en même temps qu'ils activent une disposition propre à leur groupe professionnel, se construisent comme garant de la continuité. En outre, cela leur permet aussi d'affirmer l'indépendance de la Cour par rapport aux bouleversements politiques : en faisant référence à un cadre juridique antérieur, elle établit qu'elle ne répond pas à des injonctions politiques actuelles (Ibid., p.36).



Deuxièmement, les réformes permettraient à la Cour de se recentrer sur sa raison d'être, son rôle normatif, et d'assurer son rayonnement. Bézio en est par exemple convaincu. En 1990, après avoir brièvement exposé le bilan de l'activité, il ajoute : « Cependant, il est possible de parvenir à un meilleur résultat non seulement sur le plan numérique mais encore et surtout sur le plan fonctionnel pour restituer à notre juridiction son rôle essentiellement normatif. » En 2005, Canivet affirme à son tour : « Si elle mobilise ces forces neuves, attentives au monde à partir de la tradition française, l'accélération du mouvement de réforme est une nouvelle chance pour l'avenir de notre Code civil. » Lamanda, en 2010, se félicite, lui, de la dématérialisation de la procédure : « Être plus efficace, c'est, pour la Cour de cassation, pouvoir mieux remplir sa mission première : [...] » Arens termine ainsi son discours en 2020 : « soyons toutefois résolument confiants en la capacité qui a toujours été la nôtre, à nous adapter aux grands défis mondiaux et nationaux de demain, tout en gardant notre identité. » ce faisant, les chefs de Cour actent la « distinction sémantique entre « institution judiciaire » et « administration judiciaire » » (Dumoulin et Delpuech, 1997, p.113). Ils peuvent ainsi présenter les réformes (portant sur l'administration) comme étant au service de la Justice (comme institution indépendante garante de la démocratie et comme valeur morale) et des justiciables.

Troisièmement, les chefs de Cour mettent en regard la nature évolutive et respectueuse de la Cour et les attentes des réformateurs. Ceux pointés explicitement dans les discours sont les gardes de Sceaux Robert Badinter et Elisabeth Guigou, le président Jacques Chirac, les institutions européennes et les agences américaines d'évaluation. D'autres instances, plus évasives, sont aussi convoquées : l'air du temps⁷, l'Europe, l'opinion publique. Cependant, si cela n'est pas mentionné, certains hauts magistrats sont aussi pour une part à l'origine de réformes affectant la justice. En effet, deux tiers des 15 orateurs pour lesquels on a pu établir le parcours⁸ présentent des trajectoires hybridant fonctions judiciaires et fonctions politiques. Par exemple, Jean-Louis Nadal, procureur général de 2004 à 2011, a notamment appartenu aux cabinets des ministres Robert Badinter (1983 - 1985) et Michel Crépeau (1985 - 1986) et présidé en 2013 une commission pour la modernisation de l'action publique sous Christiane Taubira⁹. Les magistrats ne font donc pas que répondre à une exigence extérieure, certains sont initiateurs des changements. Le lien se traduit par la présentation de la capacité d'adaptation de la Cour, de son ouverture sur la société et de sa loyauté¹⁰ envers les choix législatifs de l'Etat. L'adaptation est une notion centrale dans le discours libéral dominant. Elle a une fonction idéologique forte puisqu'elle instille l'idée que celui qui est inapte ou rétif au changement n'a pas de valeur (Fritsch, 2007). La Cour, pour ne pas être disqualifiée, veut montrer qu'elle est capable de suivre les directives imposées et même d'aller au-delà en étant force de propositions. Ainsi, quand il n'est pas directement question d'« être partie prenante

⁷ C'est l'instance la plus floue. On pourra lire tour à tour : « la mode », « notre époque » (Schmelk, 1980), l'« évolution des sociétés occidentales » (Arpaillange, 1995), « un monde qui s'interroge » (Marin, 2015) ou encore « L'évolution du monde », « les changements du monde » (Louvel, 2015). Il faut « être à l'écoute du monde » (Rozès, 1985) ou « de son temps » (Nadal, 2005). Aucune entité précise n'est mentionnée, la Cour suit alors une logique imperceptible mais ayant des effets certains.

⁸ Sur les 18 discours étudiés, on compte 16 intervenants, dont on ne connaît pas pour l'un le parcours.

⁹ Pour comprendre en profondeur les liens entre les sphères judiciaires et politiques dans le cadre de l'établissement de réformes, on renvoie à l'ouvrage d'Antoine Vauchez et Laurent Willemez, *La justice face à ses réformateurs (1980-2006)*, PUF, 2007.

¹⁰ La loyauté envers la loi et un des piliers de la déontologie des magistrats. Voir le chapitre IV du recueil des obligations déontologiques des magistrats. Disponible en ligne.



dans l'œuvre de modernisation » (Rozès en 1985), ou de se soumettre à la dynamique de la réforme d'Etat (Canivet en 2005), les chefs de Cour veulent apporter la preuve du dynamisme de leur juridiction. Nous nous limitons à lister certains des termes et syntagmes observés : *amélioration, mouvement, évolution, renouveau, progrès, droit vivant, renouvellement des méthodes, réforme, remodeler en profondeur l'institution, rénovation, révolution des méthodes de traitement, dynamisme, faire face au ou relever le défi*, etc. Le monde change et la Cour avec lui et ce de 1980 où Bellet apporte le « témoignage d'une prise de conscience et du désir de voir rajeunir [...] l'esprit qui préside à son fonctionnement », à 2020 « Ce large mouvement est à l'image de l'évolution de la Cour » (Molins). La Cour est donc en mesure de répondre aux demandes des réformateurs sans se trahir. Son « loyalisme [...] envers le pouvoir politique » (Bancaud, 1989, p.39) s'observe par la mobilisation de la parole ou des impératifs des réformateurs. En effet, si ouvrir leur discours à d'autres voix pouvait leur permettre de s'en désolidariser ou de le mettre à distance, ce n'est pas le cas dans notre corpus. Au contraire, la référence à ces instances fonctionne comme des arguments d'autorité : la linéarité des discours politiques, leur caractère figé et stabilisé (Krieg-Planque, 2015, p.115), et la logique économique libérale ne sont pas déconstruits. Les réformes s'imposent en raison du statut de ceux qui les commandent ou parce qu'ils les soutiennent. Les chefs de la Cour rappellent l'exigence de respect qu'elle a envers les institutions Républicaines et le gouvernement.

La manière dont les discours prennent en charge les injonctions de ces instances contribue à les ancrer dans une posture d'acceptation et de fidélité. Les orateurs peuvent directement s'adresser à une personnalité politique présente, ou mobiliser le discours rapporté. Rozès illustre le premier cas ainsi : « Monsieur le garde des Sceaux, vous nous avez convié à moderniser la Justice. », tout comme Canivet en 2000 « votre volonté de moderniser la justice ». Le discours de Schmelck, en 1980, exemplifie, lui, le second cas de figure :

Comme le recommandait ce matin encore le président de la République à l'ensemble des corps constitués : « Dans la décennie qui s'ouvre, il nous faudra inventer. » / Pour ce qui nous concerne, cet effort d'imagination devra porter sur l'aménagement des méthodes de travail [...].

La référence est parfois incluse de façon plus discrète dans le corps de la phrase, comme lorsque Nadal s'exprime en 2005 : « Il ne m'a cependant pas échappé que la nette séparation des travaux du siège et du parquet général, ainsi que l'exigent les standards européens, a ouvert de vastes perspectives de réorganisation. » Le parquet doit évoluer « dans la droite ligne des préceptes dégagés à Strasbourg. » Les orateurs, moins fréquemment, retracent le parcours des injonctions :

le droit français est, dans l'ordre mondial, brutalement appelé à l'impératif d'efficience par des écoles américaines d'analyse économique des facteurs de développement. [...] / Comme vous l'avez prévu et puissamment organisé, Monsieur le Ministre de la justice, ces analyses, [...] nous imposent, en même temps, un programme ambitieux de modernisation de notre appareil légal et juridictionnel. (Canivet en 2005)

La mention des instances réformatrices est ensuite relayée par un foisonnement de propositions déontiques telles que « il faut », « il convient », « on doit », « il est indispensable », « il est nécessaire ». Elles projettent la Cour dans un fonctionnement futur.

Enfin, les orateurs se construisent comme les garants de l'unité de la Cour. En fait, les chefs de Cour, par leurs attributions, sont susceptibles de se trouver à la croisée de dynamiques contraires, notamment celles qui opposent les magistrats réformistes et les magistrats plus conservateurs. Pour autant, ils doivent assurer l'unité de l'institution, celle qui en fait une



« instance de cohérence et de permanence » (Bancaud, 1989, p.43). L'unité est construite en discours par la mention de tensions provoquées par des changements mais finalement ou bientôt apaisées. Rozès, en 1985, relate à propos de l'adoption de nouvelles méthodes qu'elles font : « naître chez quelques-uns un certain scepticisme, sans doute pour mieux se laisser convaincre par la suite... » En 2000 Canivet évoque « Ce mouvement d'ampleur, que certains estiment trop lent et timide mais d'autres intempestif, [...] ». En assemblant les deux visions du changement entre des virgules, il (r)établit l'unité du corps.

Cette étude nous permet de prendre la mesure de l'appropriation de la rhétorique managériale par les chefs de la Cour de cassation. En effet, les discours ne constituent pas un combat idéologique entre les réformateurs et les hauts magistrats. Au contraire, leur manière de faire tenir ensemble un certain « art du bien dire » (Farcy, 1998, p.78) avec cette rhétorique les présente comme des acteurs capables de réformer la Cour pour mieux conserver son unité et son autorité. Réaffirmer l'éthos de continuité est donc une manière pour les chefs de la Cour de cassation de répondre à leur devoir professionnel et de garantir le « changement dans la continuité » (Bancaud, 1987, p.377).

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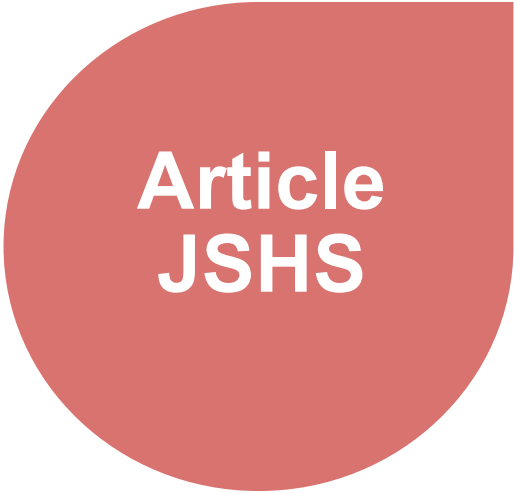


Tableau des discours étudiés

Année	premier président	procureur général
1980	Pierre Bellet	Robert Schmelck
1985	Simone Rozès	Pierre Arpaillange
1990	Pierre Draï	Pierre Bézio
1995	Pierre Draï	Pierre Truche
2000	Guy Canivet	Jean-François Burgelin
2005	Guy Canivet	Jean-Louis Nadal
2010	Vincent Lamanda	Jean-Louis Nadal
2015	Bertrand Louvel	Jean-Claude Marin
2020	Chantal Arens	François Molins







Article JSHS

The Effects of a Bike Active Video Game on Players' Physical Activity and Motivation

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Contexte

Le contexte de cette étude repose sur une collaboration internationale d'ELLIADD impliquant l'université de Minnesota aux États-Unis, l'université Catholique de Louvain-La-Neuve en Belgique et l'université de Bretagne Occidentale en France. Cette collaboration porte sur la thématique de l'utilisation des jeux vidéo actifs dans la promotion de l'activité physique. Elle a donné lieu à plusieurs productions scientifiques :

- Gao, Z., Pope, Z., Lee, J.E., Stodden, D., Roncesvalles, N., **Pasco, D.**, Huang, C.C., & Feng, D. (2017). Impact of exergaming on young children's school day energy expenditure and moderate-to-vigorous physical activity levels. *Journal of Sport and Health Science*, 6(1), 11-16 [Impact Factor: 7.179].
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<https://www.tandfonline.com/doi/full/10.1080/02701367.2016.1194123>
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Problématique de l'article

Cet article développe pour la première fois dans la littérature une approche appelée « design-based exergames approach » dans laquelle chercheurs, concepteurs de jeux et professionnels de santé collaborent pour concevoir des jeux vidéo actifs permettant de promouvoir une activité physique chez les joueurs compatibles avec des objectifs de santé. Cette approche est particulièrement originale dans la mesure où elle rompt avec la littérature dans ce domaine consistant à mobiliser des jeux vidéo actifs développés par des acteurs commerciaux qui n'ont pas démontré leur potentiel pour promouvoir chez les joueurs une activité physique compatible avec des objectifs de santé.

Cette étude apporte donc pour la première fois dans la littérature internationale des évidences empiriques sur l'efficacité d'une approche de type « design-based exergames » pour développer un jeu vidéo actif favorisant la promotion de l'activité physique des joueurs à des niveaux compatibles avec des objectifs de santé. Les résultats montrent que le jeu actif développé dans le cadre d'une « design-based exergames approach » conduit les joueurs à passer 90% de leur temps dans le jeu à des niveaux d'activité physique compatible avec des objectifs de santé et que les joueurs témoignent d'une motivation forte à s'engager dans ce type de jeu et d'activité physique.

Cette première publication mobilisant cette approche a été complétée par plusieurs autres :

- **Pasco, D.** & Roure, C. (2022). Situational Interest Impacts Young Adults' Physical Activity in a Design-Based Bike Exergame. *Journal of Sport and Health Science*, 11, 172-178 [Impact Factor: 7.179].
<https://www.sciencedirect.com/science/article/pii/S2095254621000284> ou <https://doi.org/10.1016/j.jshs.2021.03.003>
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Journal of Sport and Health Science (JSHS)

Le journal of Sport and Health Science (JSHS) est un journal international multidisciplinaire basé sur une évaluation par les pairs et dédié à l'avancement dans les sciences du sport, de l'exercice, de l'activité physique et de la santé. Il est hébergé au département des sciences du sport de l'université de Shanghai et est publié sur la plateforme Elsevier. L'impact facteur de ce journal est de 7.179 le plaçant au 3^{ème} rang sur 88 des publications scientifiques internationales dans le domaine des sciences du sport. Il est indexé sur 15 bases de données internationales.

Impact de notre article

L'impact dans la communauté scientifique de cet article peut être appréciée de plusieurs manières. Tout d'abord, la plateforme Google Scholar indique qu'il a été cité 59 fois depuis sa publication. Enfin, sur la plateforme ResearchGate (RG), il recueille un score d'intérêt en recherche de 33.9, a été recommandé 4 fois et lu par 268 lecteurs. Selon cette plateforme, ces scores placent cette publication a un niveau d'intérêt en recherche se situant dans les 17% des articles ayant le plus d'intérêt en recherche dans la communauté de plus de 20 millions de chercheurs ayant rejoint cette plateforme. Enfin, le succès de cette publication a conduit l'éditeur en chef de la revue à nous proposer de participer à un numéro spécial sur cette thématique publié tout récemment.



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Original article

The effects of a bike active video game on players' physical activity and motivation

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Abstract

Background: Players may not acquire adequate levels of moderate-to-vigorous physical activity (MVPA) when playing commercial video games. This study's goal was to evaluate the effects of an exercise bike video game played by using a mobile application-based exergame that was designed exclusively to promote participants' MVPA, with additional attention paid to this game's ability to promote greater situational interest.

Methods: An experimental design was used with 163 students (aged 20.31 ± 1.30 , 18–26 years, 61.3% male), all of whom were randomly allocated into an experimental group and a control group. Physical activity (PA) levels were assessed with ActiGraph GT3X+ (ActiGraph Inc., Fort Walton Beach, FL, USA) accelerometers. The situational interest scale was used to evaluate students' situational interest in both groups. Multivariate analysis of variance was conducted to examine the differences between sedentary behavior, PA levels, and situational interest between groups. Regression analyses were also used, with the purpose being to evaluate the strength of the relationship between PA and situational interest. **Results:** Results revealed that the experimental group had higher degrees of sedentary behavior, light PA, total interest, instant enjoyment, exploration intention, attention demand, novelty, and challenge, whereas the control group received higher scores for MVPA (control 95.01% vs. experimental group 89.94%). Regression analysis indicated that instant enjoyment ($\beta = 0.49$, $p < 0.01$), exploration intention ($\beta = 0.18$, $p < 0.05$), and attention demand ($\beta = 0.17$, $p < 0.05$) were positive predictors for total interest, explaining 43% of its variance.

Conclusion: A newly designed mobile application-based exergame played via an exercise bike may enhance situational interest and provide a decent level of PA for players.

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Keywords: Design; Exergame; Moderate-to-vigorous physical activity; Sedentary behavior; Situational interest; Young adults

1. Introduction

From 1975 to 2014, researchers from the Non-Communicable Diseases Risk Factor Collaboration Consortium reviewed population studies from approximately 200 countries in adults aged ≥ 18 years to determine body mass index (BMI) changes over time.¹ Findings from this comprehensive review indicated that average BMI increased from 21.7 kg/m^2 in 1975 to 24.2 kg/m^2 in 2014 in men, and from 22.1 kg/m^2 to 24.4 kg/m^2 in women. The study also revealed that if the post-2000 trends continue, by 2025, global obesity prevalence will reach 18%

in men and surpass 21% in women, with severe obesity (i.e., $\text{BMI} \geq 35 \text{ kg/m}^2$) surpassing 6% in men and 9% in women. To mitigate this trend, researchers have focused on promoting proper health behaviors in youth and young adults to improve BMI values and reduce potential adverse health consequences associated with overweight or obesity.^{2,3}

The current generation's youth and young adults are highly involved in social media⁴ and video games.^{5–7} Lenhart et al.⁵ reported that 65% of males and 35% of females aged 12–17 years are daily gamers, whereas Gentile⁶ found that 88% of American youth aged 8–18 years play video games at least once a month. According to Ream et al.,⁷ this trend in video game play and social media interaction starts in early childhood and continues through adulthood. As such, leveraging the technology that most interests the current generation's youth and young adults in an

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effort to improve health outcomes in later life has become the focus of a growing body of research and practice.

In 2005, Nintendo (Redmond, WA, USA) launched the Wii, the first video game console in which players interacted with games through bodily movement. These types of games and gaming consoles would later be termed “exergames” (as known as active video games), which in contrast to sedentary video games have been defined as “video games that are also a form of exercise”.⁸ Exergames have received increasing attention among researchers because they offer a unique opportunity to build on youth and young adults’ interest in video games, with the objective being to address the obesity crisis through increased physical activity (PA). Over the past 10 years, numerous studies have been published related to the effect of exergames on youth and adults’ PA levels.^{9–13} Indeed, Peng et al.¹⁴ published a meta-analysis regarding the use of exergames for PA promotion among youth (6–17 years old) and adults (≥ 18 years old). Findings indicated that exergames (1) significantly increased heart rate, oxygen consumption, and energy expenditure compared with sedentary behaviors; (2) produce a similar magnitude of effect as light- to moderate-intensity PA; (3) have a similar impact for youth and adults with regard to PA intensity; and (4) are more attractive and enjoyable for youth and adults in comparison to traditional PA. Taken together, these findings suggest exergames to be a viable option to promote youth and adults’ PA and health.

Despite the aforementioned benefits, youth and adults may still not acquire adequate levels of moderate-to-vigorous PA (MVPA) when playing commercial exergames (e.g., Wii Sports, Wii Fit, Dance Dance Revolution, Xbox Kinect, *etc.*). According to Beaudoin,¹⁵ designers in the commercial exergames industry focus more on the fun and entertaining features of exergames—as opposed to aspects of game design that might increase PA intensity and subsequent health benefits—given the fact that the goal of commercial exergames is still primarily to entertain.

1.1. (Exer)games design

Despite knowing that video games can be effective educational tools,^{16–18} it is still unclear how and under what conditions these games are effective. According to Gaydos,¹⁹ video game design remains poorly understood. Indeed, designing a good video game is difficult. One way to improve the design process is to share design plans. In the literature, researchers have shared video game designs via journal articles that present design principles or a list of steps that one must follow to create or recreate a game.^{20–25} Briefly, these literature reports indicate the importance of designing games that immerse the player in a virtual world where competition and autonomy are present, real-world social norms can be temporarily ignored, and there is a need to find solutions to within-game problems to achieve success.²⁰

In line with these design needs, Wang and Hannafin²¹ introduced a design-based research perspective defined as “a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and

practitioners in real-world settings, and leading to contextually sensitive design principles and theories”. Simply put, researchers should ensure that every aspect of game design is consistent with the intended user population and overall objective of the game (e.g., to educate players on a subject, or to increase PA in players)—with the result being a more effective video game. Among the best examples of the use of the aforementioned design principles and design-based methodology comes from the Quest Atlantis team,²² who successfully developed a video game that enhanced children’s engagement in educational tasks. Given the proven effectiveness of these design principles and this methodology, these factors also need to be at the forefront of researchers’ minds when developing video games for noneducational purposes (e.g., MVPA promotion among youth and/or young adults) to ensure achievement of the intended outcome.

1.2. Designing a mobile application-based exergame for an exercise bike

Despite the attractiveness of exergames among youth and adults,¹⁴ few studies have investigated players’ situational interest during exergame play.^{26–29} Situational interest has been defined as an activity’s appealing effect on an individual(s)³⁰ and emerges from an instant person–activity interaction in which the person recognizes a specific intriguing feature of this activity while being engaged in the activity.³¹ According to Hidi and Harackiewicz,³² a highly interesting activity can immediately attract individuals’ attention and provide positive feelings about the activity. Within the context of PA, Chen et al.^{33,34} identified 5 sources of situational interest: novelty, challenge, attention demand, exploration intention, and instant enjoyment. The aforementioned sources of situational interest have been investigated among children while playing exergames.

Sun^{26,27} found that elementary school students’ situational interest during an exergaming unit was higher than their situational interest in a traditional fitness unit, with their situational interest decreasing significantly over time during the latter fitness unit. Additionally, Huang and Gao²⁸ found that novelty was a significant predictor of MVPA during exergame play in middle school students. Finally, Roure et al.²⁹ found that high school students displayed a higher level of MVPA when they believed that the activity demanded greater attention and demonstrated a higher level of light PA when they deemed the activity to only provide novelty.

Therefore, to promote players’ MVPA and situational interest throughout game play, Vescape GmbH (Berlin, Germany) designed a mobile application called Greedy Rabbit based on the design principles of trial-and-error and progressive challenges and feedback.³⁵ Broadly, the mobile application-based exergame encompasses 10 sets of 10 stages representing progressively harder challenges. In detail, Greedy Rabbit is a maze game in which a rabbit makes its way through a maze, collecting flowers and avoiding hedgehogs in chase, with the goal being to obtain a carrot placed at the end of each maze (i.e., game stage). The video game is compatible with any mobile device (e.g., tablet, smartphone) and is paired with an exercise bike via a Bluetooth (Bluetooth SIG Inc., Kirkland, WA, USA) connection to match the speed of the rabbit with the player’s

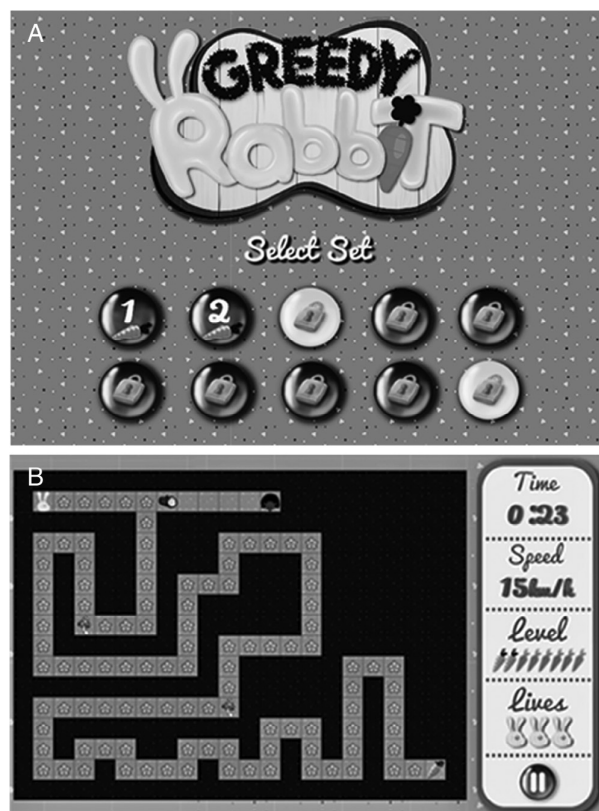


Fig. 1. Screen shots of Greedy Rabbit exergame. Greedy Rabbit home screen (A) and example of 1 level (B).

cycling speed. Furthermore, this wireless connection allows the resistance of the exercise bike to increase or decrease depending on events that occur in the game (e.g., collecting a mushroom). Players are provided with 3 lives to complete the 10 stages and lose a life each time they are caught by a hedgehog. Greedy Rabbit is included in the Vescape app available from Google Play or Apple's App Store and capitalizes on the high percentage of smartphone ownership and the desire for health apps among consumers.^{36,37} Pictures of the interface and levels are presented in Fig. 1.

Given the preceding literature review, the following questions guided the current study: (1) To what extent does the Greedy Rabbit exercise bike video game promote players' MVPA and situational interest? and (2) what source(s) of situational interest have the greatest impact on players' MVPA? Participants were college students because little study of exergaming has been completed among this population. In fact, owing to the major life changes and increased responsibility brought about during college, college students are at risk of low levels of PA and higher rates of obesity³⁸—necessitating innovative forms of exercise to motivate this population to be more active and to improve health outcomes. The findings of the study will inform researchers and practitioners about the effectiveness of an exercise bike paired wirelessly with a mobile application-based exergame on players' MVPA and situational interest. Additionally, findings will demonstrate how best to

facilitate greater MVPA and situational interest for the greatest health impact among young adults.

2. Methods

2.1. Participants and research design

An experimental design was used to examine how 2 different exercise protocols affected the relationship between objectively measured PA levels and self-reported situational interest. The participants in the study were a convenience sample of 163 undergraduate students (aged 20.31 ± 1.30 , 18–26 years, 61.3% male) recruited from the sport science department of a French university located in the northwest region of France. Notably, the current study was not part of students' course load and was purely voluntary. Permission to conduct the study was granted by the ethical board of the University of Western Brittany. Students were informed about the scope of the study, with written informed consent gathered prior to data collection. Participants were included based on the following criteria: (1) between 18 and 26 years old and (2) no reported health issues.

Participants were randomly allocated into 2 groups: an experimental group ($n = 94$) and a control group ($n = 69$). For the purposes of the current study, we desired a higher number of individuals in the experimental group than in control group. In the experimental group, students engaged in one 15 min session of the Greedy Rabbit exergame—consisting of the first set of 10 stages—using an exercise bike paired wirelessly via Bluetooth with the mobile application-based exergame. In the control group, participants engaged in one 15 min session of free cycling on an exercise bike and were told to act as if they were in a fitness center. Students in the control condition chose the level of difficulty and the cycling cadence during the 15 min session. During this session, students from the control group were informed by the exercise bike's screen about the time left, their cycling cadence, and their power output.

2.2. Measures

2.2.1. Situational interest

The 19-item French Situational Interest Scale (FSIS)³⁹ was used to measure students' situational interest during the exergame. The scale included 5 situational interest subscales, each representing a source of situational interest: novelty (e.g., "what I did today was new to me"), instant enjoyment (e.g., "what I did was enjoyable for me"), exploration intention (e.g., "I wanted to analyze and have a better handle on what I was learning today"), attention demand (e.g., "what I was learning demanded my high attention"), and challenge (e.g., "what I was learning was hard for me to do"). Subscales for each source of situational interest consisted of 3 items. Total interest was also measured and consisted of 4 items. The items were randomly arranged, and each was rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Among middle and high school students, Roure et al.³⁹ established the construct validity of the FSIS using exploratory and confirmatory factor analyses, in addition to reporting internal consistency for all 5 sources of situational interest.

2.2.2. PA levels

ActiGraph GT3X+ (ActiGraph Inc., Fort Walton Beach, FL, USA) accelerometers were used to assess student PA levels. These accelerometers measure motion in 3 dimensions and provide triaxial vector data to calculate metabolic equivalents in relation to participants' demographic and anthropometric characteristics. The devices are 4.6 cm × 3.3 cm × 1.5 cm in size and can be worn on the wrist, waist (hip), arm, thigh, or ankle. In this study, students wore the accelerometer on the ankle using an elastic strap. The ankle has been shown to be the best location for providing PA data during cycling.⁴⁰

The GT3X+ is widely used in PA research and has demonstrated acceptable criterion validity and reliability for recording PA in the field and converting activity counts into different intensity levels of PA.⁴¹ Accelerations from the ActiGraph GT3X+ were converted into activity counts, summed, and recorded using a specified interval of time called an epoch, which can range from 5 s to 1 min. In the present study, the epoch was set to 5 s. Cut-points were established using the same methodology as Puyau et al.'s study.⁴² Specifically, cut-points for activity counts were as follows: sedentary behavior (0–399 counts per 30 s), light PA (400–1599 counts per 30 s), and MVPA (≥1600 counts per 30 s). The percentages of time that students spent in sedentary behavior, light PA, and MVPA were used as the outcome variables.

2.3. Data collection

This study took place during the spring semester of the 2016 school year. Researchers collected demographic and anthropometric information, such as age, gender, height, weight, and dominant foot, for all participants. This information was needed prior to the accelerometer's placement on the ankle to initialize the accelerometers via the ActiLife software (Vescap GmbH) and to collect accurate PA measures.

The accelerometers were collected after each 15 min session, and the data were immediately downloaded to a data collection computer. Students also responded to the FSIS immediately after the session. Researchers administered the questionnaire and collected it immediately after completion. To minimize students' tendency to give socially desirable responses, students were encouraged to answer honestly and were assured that their responses would remain anonymous and confidential.

2.4. Data analysis

Students' responses were aggregated respectively to the 5 sources of situational interest (instant enjoyment, exploration intention, attention demand, challenge, and novelty) and to total interest. The statistical analyses were then performed in the following steps. Preliminary analyses were first conducted on study variables to examine normality, multicollinearity, and internal reliability of the subscales. Next, a multivariate analysis of variance was conducted to examine the differences between the dependent variables within a multivariate framework. The dependent variables were the participants' PA levels (sedentary behavior, light PA, and MVPA), the situational interest sources (instant enjoyment, exploration intention, attention

demand, challenge, and novelty), and total interest. The independent variables were group membership (experimental or control) and gender (female or male). Pillai's F statistic was used to determine the statistical significance of the multivariate model because this statistic "can help control the type I error rate with small or unequal sample sizes".⁴³ Follow-up univariate tests were then conducted based on the statistical significance of the multivariate analysis of variance test. A Bonferroni *post hoc* test was employed if there were any statistically significant differences in the participants' percentage of time in sedentary behavior or at differing PA levels in addition to assessing differences in total interest and situational interest sources. Finally, Pearson product-moment correlations and multiple regression were used, within the experimental group, to analyze the relationship between situational interest sources, total interest, and participants' PA levels. SPSS Version 23.0 (IBM Corp., Armonk, NY, USA) was used for all statistical analyses.

3. Results

Analysis of the skewness (−1.60 to 1.95) and kurtosis (−1.81 to 2.28) values revealed that data were normally distributed. Multicollinearity was checked using the variance inflation factor and tolerance statistics in SPSS. Neither variance inflation factor values greater than 10 nor tolerance values below 0.2 were found, indicating no multicollinearity between the variables. The mean substitution technique⁴⁴ was chosen to replace each missing score owing to the small number of missing scores among the sample (<0.01%). Internal consistencies were good for the situational interest scale, with Cronbach's α of 0.94 for instant enjoyment, 0.90 for exploration intention, 0.91 for attention demand, 0.71 for challenge, 0.88 for novelty, and 0.92 for total interest, respectively.

Table 1 reports the means, SD, and differences between the 2 groups for PA levels, situational interest sources, and total interest measures. The results from multivariate analysis of variance revealed a significant main effect of group membership on participants' PA levels and total interest scores (Pillai's trace = 0.89; $F(9, 151) = 141.50$; $p < 0.001$; $\eta^2 = 0.89$), whereas the multivariate effects of gender were not significant (Pillai's trace = 0.07; $F(9, 151) = 1.32$; $p = 0.23$; $\eta^2 = 0.07$). In follow-up Welch analyses of variance, with an α of 0.025, it was determined that mean

Table 1
Descriptive data of PA levels and situational interest measures.

	Range	Experimental		Control		$F(1, 161)$	η^2
		M	SD	M	SD		
Sedentary	0–100	4.76	6.33	1.06	2.89	20.40**	0.11
Light PA	0–100	5.32	2.90	3.93	2.79	9.45**	0.06
MVPA	0–100	89.94	6.86	95.01	3.58	31.47*	0.16
Total interest	4–20	15.39	2.89	7.72	2.55	309.29**	0.66
Instant enjoyment	3–15	13.09	1.83	6.42	2.20	443.17**	0.73
Exploration intention	3–15	10.31	2.66	4.99	1.92	200.13**	0.55
Attention demand	3–15	7.48	2.91	3.90	1.35	89.87**	0.36
Novelty	3–15	14.29	1.92	4.00	2.22	1001.08**	0.86
Challenge	3–15	4.41	1.73	3.88	1.40	4.38*	0.03

* $p < 0.01$, ** $p < 0.001$.

Abbreviations: MVPA = moderate-to-vigorous physical activity; PA = physical activity.

Table 2

Correlations among PA levels, situational interest sources, and total interest.

	1	2	3	4	5	6	7	8	9
1. Sedentary	—								
2. Light PA	−0.04	—							
3. MVPA	−0.91**	−0.38**	—						
4. Total interest	0.05	0.03	−0.06	—					
5. Instant enjoyment	−0.11	0.14	0.04	0.62**	—				
6. Exploration intention	0.03	0.14	−0.09	0.41**	0.41**	—			
7. Attention demand	0.01	−0.13	0.04	0.26**	0.13	0.05	—		
8. Novelty	0.06	0.17	−0.13	0.05	0.05	0.00	−0.20*	—	
9. Challenge	0.01	−0.06	0.02	0.15	0.01	0.06	0.36	−0.13	—

* $p < 0.05$, ** $p < 0.01$.

Abbreviations: MVPA = moderate-to-vigorous physical activity; PA = physical activity.

scores for participants' PA levels, situational interest sources, and total interest differed significantly between the experimental group and the control group. *Post hoc* tests using the Bonferroni correction revealed a significant difference between the groups on sedentary behavior (4.76% vs. 1.06%; $p < 0.001$), light PA (5.32% vs. 3.93%; $p < 0.001$), total interest (15.39 vs. 7.72; $p < 0.001$), instant enjoyment (13.09 vs. 6.42; $p < 0.001$), exploration intention (10.31 vs. 4.99; $p < 0.001$), attention demand (7.48 vs. 3.90; $p < 0.001$), novelty (14.29 vs. 4.00; $p < 0.001$), and challenge (4.41 vs. 3.88; $p < 0.01$), whereas the control group received higher values for MVPA (95.01% vs. 89.94%; $p < 0.01$).

The Pearson's correlation coefficients presented in Table 2 indicated that neither total interest nor the 5 situational interest sources correlated significantly with PA levels. Additionally, the results showed that total interest correlated positively and moderately high to instant enjoyment ($r = 0.62$; $p < 0.01$), moderately to exploration intention ($r = 0.41$; $p < 0.01$), and lowly to attention demand ($r = 0.26$; $p < 0.01$). Moreover, moderate correlations between instant enjoyment and exploration intention were positive ($r = 0.41$; $p < 0.01$), whereas attention demand and novelty correlated negatively ($r = -0.20$; $p < 0.05$). Multiple-regression analyses were conducted to examine whether situational interest sources could predict total interest. Regression analysis revealed that instant enjoyment ($\beta = 0.49$; $p < 0.01$), exploration intention ($\beta = 0.18$; $p < 0.05$), and attention demand ($\beta = 0.17$; $p < 0.05$) were positive predictors for total interest, explaining 43% of its variance.

4. Discussion

Research has revealed that commercial exergames produce a magnitude of effect equivalent to light- to moderate-intensity PA.¹⁴ Thus, the Vescape company designed a mobile application-based exergame platform, Greedy Rabbit, to be paired wirelessly via Bluetooth with an exercise bike, with the objective to promote players' MVPA. The goal of this study was to evaluate the effects of this Vescape exergaming platform on players' MVPA and, further, their situational interest.

4.1. PA and situational interest

Descriptive analyses indicated that players spent approximately 90% of their time in MVPA when playing the exergame

on the exercise bike. This result differs from several studies in the relevant literature. Willems and Bond⁴⁵ observed greater proportions of light PA, as opposed to MVPA, in students aged 20–22 years old during exergame play (Wii Sports), with similar results seen in a study by Worley et al.⁴⁶ in students (mean age, 22.88 years old) playing a traditional commercial exergame (Wii Fit). Moreover, Lyons et al.⁴⁷ also recorded low-moderate PA in 100 adults aged 18–35 years playing 3 commercial exergames (Guitar Hero III, Dance Dance Revolution, and Wii Fit). The preceding literature is in agreement with a meta-analysis by Peng et al.¹⁴ wherein of the 14 studies included, 12 studies reported light- to moderate-intensity levels of PA when playing exergames, with only 1 study reporting MVPA and another a vigorous intensity of PA.

Given the current study's favorable MVPA comparisons to previous literature, a designed mobile application-based exergame played via an exercise bike may provide health-related benefits to players.⁴⁸ However, it is worth noting that students in the control group spent 95% of their time in MVPA when asked to pedal on the exercise bike for 15 min—slightly higher than observed in the experimental group. This finding has 2 plausible explanations. First, in studying motivation and PA among sport students in 3 countries, Kondric et al.⁴⁹ found a “high motivation profile”, in which students had high intrinsic and extrinsic motivation and low levels of amotivation (i.e., a lack of motivation) for PA. In essence, these students' chosen area of study (i.e., sport science) explained their highly motivated attitude and high levels of participation and proficiency in numerous PAs. Congruent with the aforementioned literature, findings from the current study with regard to the control group's high MVPA may also be explained by these students' motivational profile because all participants were sport science students. Second, it might be that because of the novelty of the Greedy Rabbit game among the experimental group, participants in this group might have spent a portion of the 15 min exercise session trying to learn how to play the game. This is important, because this learning process may have lowered the PA intensity with which these participants were able to exercise to below that of the control group participants, who were simply asked to exercise as if they were in a fitness center.

Despite students in both groups exhibiting high levels of PA, situational interest was different between exercise conditions.

Specifically, differences in situational interest between the control and experimental groups were significant for each source of situational interest. As for the mechanism explaining these findings, Greedy Rabbit's unique platform (i.e., a mobile application-based exergame played with an exercise bike) likely engaged students in a new activity that promoted emotional engagement (i.e., instant enjoyment). Furthermore, as they played, students were focused on the game (i.e., attention demand) and the exploration of the game environment (i.e., exploration intention). As a result of this unique platform, instant enjoyment, exploration attention, and attention demand were observed to be positive predictors of total interest—explaining the higher situational interest among the experimental group in addition to the aforementioned higher MVPA levels. This finding is in line with literature investigating exergaming in younger populations. Sun²⁶ found that fourth-grade students experienced higher situational interest from all this construct's sources during an exergaming unit compared with a fitness unit. Moreover, Roure et al.²⁹ found that instant enjoyment was the most significant situational interest source reported by high school students as they played an exergame. Nonetheless, although Greedy Rabbit did appear to promote situational interest in PA among college students, this exergame did not appear to result in differences in MVPA among this population—perhaps owing to the highly physically motivated and fit participants in the current trial.

4.2. Impact of exergame design

Engineers from the Vescape company designed Greedy Rabbit on the basis of the design principles³⁵ of trial-and-error and progressive challenges and feedback. Our study revealed that players spent 90% of their time in MVPA when playing Greedy Rabbit on the exercise bike and that the mobile application-based exergame had the ability to promote players' total interest through instant enjoyment, exploration attention, and attention demand. Although students in the control group had approximately similar MVPA levels, low levels of situational interest from all sources were seen in this group. Although the preceding findings favor Greedy Rabbit, it is notable that this exergame did not appear to represent a physical challenge for students in the experimental group. Simply put, Greedy Rabbit's first set of 10 stages may not be difficult enough for highly fit young adults (e.g., students within a sport science department), revealing a possible design issue necessitating consideration in future iterations of the game.

As Beaudoin¹⁵ pointed out, "When examined technically, the commercial design studio relies on individual historical knowledge and game playing experience to develop new game types or adapt existing mechanics into new games." Often in the commercial gaming industry, individual designers design a game based on their own experience of effective game design tools. Challenge was one of the key design features of Greedy Rabbit, supposedly increasing the intensity of the game. Unfortunately, as stated previously, our study indicated that the challenge for the first set of 10 stages may not be sufficient for more fit young adults akin to the cohort recruited in the current study. As such, our study again suggests the need for quantifiable

design practices and peer review methodology for subsequent iterations of Greedy Rabbit as well as for other tailor-designed exergames for research and practice. Using a cycle of analysis, design, implementation, and redesign as suggested by Wang and Hannafin²¹ within design-based research methodology, the effectiveness of the game in promoting specific outcomes (e.g., more challenging gameplay and, thus, a greater challenge for highly fit populations) and user experience might be increased.

Unfortunately, the aforementioned process would significantly increase the time needed to redesign an exergame such as Greedy Rabbit or even to design a new exergame with similar objectives. In the fast-paced commercial gaming industry, an individual designer evaluates his or her design in the course of a few weeks based on player responses. Formal research is done when the value of the game is proven in the marketplace. At the time we conducted this study (February/March 2016), design choices had been made, and Greedy Rabbit had already been released in the Google Play Store (December 2015) and Apple App Store (January 2016). As can be seen, using a design-based research method with a peer review process would affect this design cycle. By the time researchers published results in a peer-reviewed journal, designers would be working on new game developments. One way to address this timing issue may be to have designers and researchers constantly interact with each other within a research and development department. Because we will collaborate with engineers from the Vescape company on future iterations of Greedy Rabbit based on results from this study, we will explore ways to target specific sources of situational motivation to promote MVPA for users of all fitness levels—not just the highly fit—in a timely process that minimally affects the previously outlined design cycle.

4.3. Limitations

Although this study offers a unique contribution to the literature given the study's use of a mobile application-based exergame wirelessly compatible via Bluetooth with an exercise bike in the promotion of college students' MVPA and situational interest, several limitations should be acknowledged. First, participants were young adult college students recruited from a department of sport science. Given the fact that this population had high levels of motivation for PA, in addition to high fitness levels, future studies should involve participants with varying motivations for PA (e.g., predominantly intrinsically, extrinsically, or amotivated) and physical fitness. Second, it appeared that the first set of 10 levels of Greedy Rabbit were not challenging for the highly fit population studied. Future studies recruiting fit populations should explore the higher and more progressive sets of levels contained within the application. Third, although this study did reveal the acute and beneficial effects of Greedy Rabbit on students' situational interest, the sustainability of players' situational interest is still unknown. Future studies should consider examining the effect of Greedy Rabbit on players' perceived situational interest over time using a longitudinal study design. Finally, although this study offers a unique opportunity to evaluate players' MVPA engagement in a designed exergaming platform, MVPA comparisons of the same players participating in traditional

commercial exergames were not conducted (i.e., Wii, Xbox). Future studies should consider a within-subjects research design in which the participants would be assessed playing a mobile application-based exergame on an exercise bike and while playing traditional exergames to determine potential difference in MVPA and other psychosocial outcomes (i.e., self-efficacy, enjoyment)⁵⁰ between the 2 exergaming modalities. Despite these limitations, the findings of this study provide initial evidence of the potential physical and psychological benefits that playing a design-based exergame may have.

5. Conclusion

The findings of the current study indicated a mobile application-based exergame capable of being wirelessly paired to an exercise bike can promote light PA, situational interest, and other important psychological determinants of PA participation versus traditional biking exercise. Moreover, the study's findings showed that this mobile application-based exergame can promote similar, but slightly lower, levels of MVPA as compared to traditional biking exercise. However, updates to this mobile application-based exergaming platform and other analogous platforms are advised to increase game difficulty and promote an intensity of gameplay akin to that observed during traditional biking exercise—particularly among healthy, physically fit, and active populations.

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Authors' contributions

DP designed the study, managed the data collection, participated in the data collection and data analysis, and drafted the manuscript (excluding the method section); CR participated in the study design and the data collection, managed the data analysis, and drafted the method section of the manuscript; GK participated in the study design and the data collection; ZP helped draft the manuscript and proofread it; and ZG participated in the study design and data analysis and helped draft the manuscript and proofread it. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

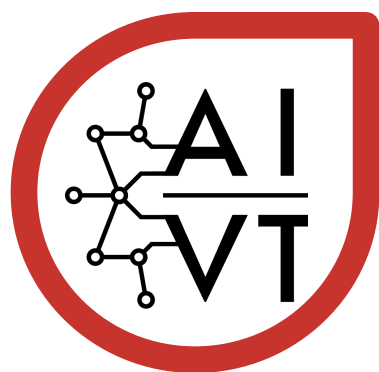
None of the authors declare competing financial interests.

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Projet FEDER

Artificial Intelligence Virtual Trainer AI-VT

<https://ai-vt.univ-fcomte.fr/>

Contexte du projet

Le projet interdisciplinaire *Artificial Intelligence Virtual Trainer* (AI-VT) s'inscrit dans le contexte de travaux sur les Environnements Informatiques sur l'Apprentissage Humain (EIAH) menés à ELLIADD, en collaboration avec le laboratoire d'informatique FEMTO-ST DISC (Département d'Informatique des Systèmes Complexes).

Le projet AI-VT porte sur "l'intelligence artificielle pour l'éducation", notamment sur les parcours personnalisés des apprenants (adaptive learning). Le projet né de la collaboration entre un chercheur en IA (Julien Henriet, FEMTO-ST DISC) et Françoise Greffier chercheuse en EIAH (ELLIADD, Pôle CCM). En 2019 deux enseignants chercheurs ont rejoint l'équipe : Marie-Laure Betbeder (MCF en informatique à l'institut FEMTO-ST DISC) et Dana Léon-Henri (didacticienne, MCF enseignante de l'anglais, au laboratoire ELLIADD, pôle CLD).

AI-VT propose une solution informatique multi-agents basé sur la méthode du Raisonnement à Partir de Cas (RàPC), qui génère des listes personnalisées et variées d'énoncés d'exercices afin de favoriser un apprentissage par entraînement.

Un projet né d'une première collaboration

Les fondements pédagogiques d'AI-VT sont les suivants :

- Organisation des connaissances en compétences disciplinaires et sous-compétences associées. Un énoncé dans la base de données est rattaché à au moins une sous-compétence.
- Un énoncé est associé à une durée impartie pour le résoudre et un niveau de difficulté.
- L'apprenant choisit une compétence à travailler en début de séance pour une durée donnée (ex : 1H30).

- En fonction des résultats de l'apprenant aux séances qui précèdent AI-VT propose des énoncés plus au moins difficiles.
- L'évaluation d'un exercice est donnée par deux indicateurs : le temps passé pour le résoudre et une note.
- Un tableau de bord propre à chaque étudiant, donne pour chaque compétence travaillée, les temps passés et les notes obtenues.

Figure 1. Exemple d'énoncés produits par AI-VT pour la programmation

Ce projet initialement soutenu financièrement par les deux laboratoires et la FR-Educ a évolué vers un projet FEDER financé à hauteur de 350 000 euros pour une durée de 24 mois (de juin 2020 à mai 2023). D'autres questions de recherche ont été intégrées, notamment l'utilisation de robots (de type NAO) pour l'apprentissage des langues sur des exercices oraux. Nao permettra aux apprenants de s'entraîner à la compréhension orale et l'expression écrite (ainsi que la prononciation, le vocabulaire, et les règles de grammaire de base). Equipé de reconnaissance vocale et capable de communiquer en 20 langues différentes, le robot NAO nous offre un potentiel conséquent (en langues étrangères, mais non seulement).



AI-VT : la didactique de l'anglais avec le robot NAO

Dans le cas de l'apprentissage de l'anglais, voit l'introduction de robots NAO qui servent d'interface pour des exercices oraux d'AI-VT, dans le but d'inciter les apprenants à découvrir de nouvelles technologies en revoyant les bases de la langue. Ces révisions servent à diagnostiquer et donc améliorer leurs compétences et leur niveau de confiance en langue étrangère pour une prise de parole d'une meilleure qualité.

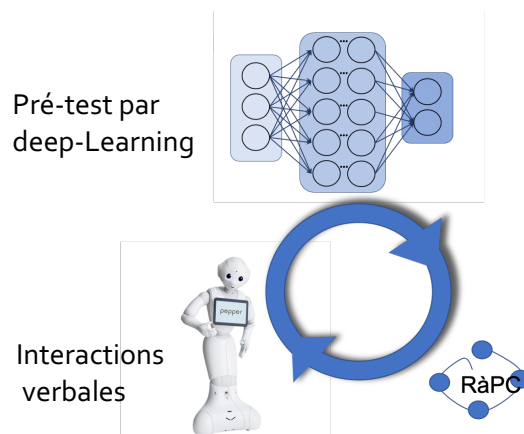


Figure 2. Extensions d'AI-VT

Une approche expérimentale

Notre approche est expérimentale, AI-VT est appliqué en situation réelle d'apprentissage afin de le tester et le faire évoluer en fonction des observations de terrain.

Nous avons ainsi testé AI-VT sur le terrain en 2016-2017 puis en 2018-2019, auprès d'étudiants de première année de licence à l'UFR ST de Besançon, dans le cadre de cours de soutien en algorithmique et programmation.

AI-VT (apprentissage de l'anglais avec des robots) a été utilisé et testé en avril 2022 dans des enseignements d'anglais pour non-spécialistes (de niveau Licence en troisième année de psychologie à l'UFR SLHS de Besançon). Dans un premier temps, un pré-test sous forme de dictogloss [dictée + glossaire] préenregistré (accent et vitesse constants) a été utilisé afin d'évaluer les compétences orales et l'expression écrite des apprenants. Ce pré-test entraîné par Deep-Learning donne les compétences et sous compétences à travailler pour chaque étudiant.

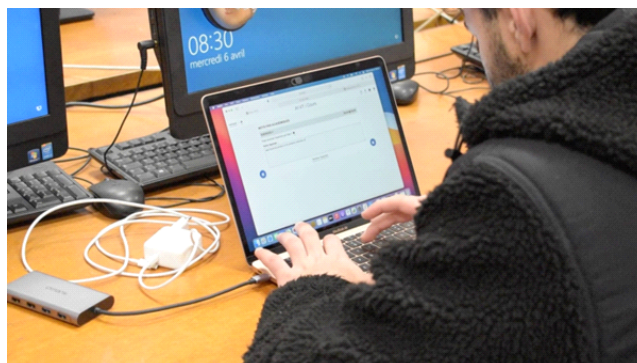


Figure 3. Étudiant sur l'application AI-VT

Dans le cadre d'une évaluation de type dictogloss, les apprenants peuvent mieux comprendre leurs erreurs afin de mieux s'approprier leur apprentissage. Si le dictogloss est basé sur leurs besoins (dans ce cas le résumé d'un article

scientifique), l'apprentissage devient ainsi plus attrayant et pertinent pour leur permettre d'aborder les exigences du monde professionnel. En parallèle la base de données d'AI-VT a été renseignée pour mener l'expérimentation ci-dessous. Une vingtaine d'étudiants en anglais (de niveau Licence en troisième année de d'Information et communication à l'UFR SLHS) ont fait le pré-test.

Ensuite AI-VT leur a proposé des exercices oraux personnalisés avec le robot Nao. Suite à cette expérience, les étudiants ont répondu à un questionnaire et l'étude des données est en cours.

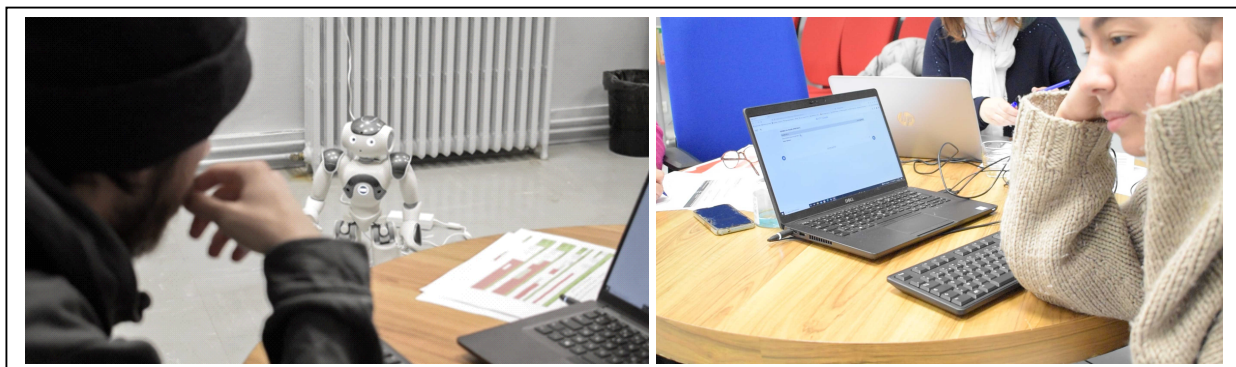


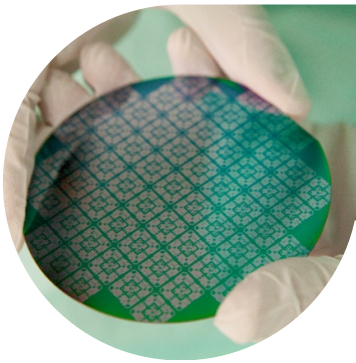
Figure 4. La compréhension orale testée à l'aide de NAO

Le financement FEDER a également fourni des moyens financiers et humains pour traiter les données d'une étude préalable (chaque année depuis janvier 2019) afin d'analyser l'évolution des perceptions des robots et de l'IA par les étudiants en langue

En résumé, les travaux de recherche menés par les chercheurs d'ELLIADD portent sur la modélisation des connaissances et sur les questions de didactique liées à la conception de du système. Les chercheurs du projet enseignant dans des disciplines différentes facilitent l'application sur des terrains distincts. Ces expérimentations permettent de tester la généricité d'AI-VT, également de collecter des données issues d'observations pour conduire des analyses concernant notamment l'acceptabilité d'AI-VT par les apprenants et la perception de l'IA par les apprenants.

Des premières réflexions sont conduites actuellement pour une version d'AI-VT qui apportera des aides contextualisées à l'apprenant lorsqu'il s'entraîne, selon ses premières réponses aux exercices proposés et en fonction de ses besoins (didactique).





PROJET PRICE

Terra3D

Contexte du projet

Le projet TERRA-3D est un projet de recherche ELLIADD qui a débouché sur une collaboration avec l'entreprise Allucyne (<https://www.allucyne.com/en/home/>). Des travaux de recherche ont été menés en condition écologique pour étudier les modèles explicatifs mobilisés par les élèves lors de la réalisation et de l'interprétation d'activités scientifiques en lien avec les mouvements de la Terre et les saisons au cycle 3 de l'école primaire. Les processus cognitifs intrinsèques aux activités de modélisation et des tâches épistémiques ont été étudiés auprès d'un groupe d'apprenants immergés dans deux types de situations : la première permettant aux élèves de manipuler des objets tangibles, la seconde intégrant des ressources pédagogiques numériques.

- Boivin-Delpieu, G. (2020). Comparaison de situations d'enseignement et d'étude des mouvements de la Terre avec des objets tangibles et des objets numériques au cycle 3. *Éducation & Didactique*, 14(3), 9-38. <https://journals.openedition.org/educationdidactique/6847> ou <https://doi.org/10.4000/educationdidactique.6847>

Sur la base des résultats de cette étude, une collaboration a été engagée avec l'entreprise Allucyne qui a débouché sur une publication centrée sur la méthodologie de conception de Terra3D, une interface numérique pour l'enseignement de l'astronomie.

- Boivin-Delpieu, G. & Joubert, P. (2021). Didactique de la physique et conception d'un simulateur pour l'enseignement de l'astronomie au cycle 3. *Sticef*, 28(1), 1-29. <http://sticef.univ-lemans.fr/num/vol2021/28.1.2.boivin/28.1.2.boivin.htm> ou DOI:10.23709/sticef.28.1.2

Les contraintes didactiques ayant guidé ce travail sont justifiées à travers plusieurs dimensions : les compétences des enseignants, les hypothèses théoriques sur l'apprentissage à travers notamment des tâches épistémiques et des activités de modélisation et les contraintes institutionnelles liées aux

concepts à enseigner. La transposition de ces contraintes dans l'interface Terra3D est aussi explicitée.

ANR : Projet PRCE et plan de relance

Sur la base de cette collaboration avec l'entreprise Allucyne, un projet ANR sur l'instrument de financement PRCE a été déposé mobilisant le laboratoire ELLIADD et l'entreprise Allucyne (48 mois ; 473k€). Ce projet a été sélectionné à l'issue de la première étape. Une version longue a été déposée qui n'a finalement pas été retenue pour financement par l'ANR. Nous avons alors mobilisé l'opportunité du dispositif de plan de relance pour déposer un projet LabCom. L'ANR a retenu ce projet pour un montant de **240k€**. Ce financement a permis le recrutement de deux postes au sein de l'entreprise Allucyne.

L'environnement numérique Terra3D développé sur la base des travaux de recherche menés au sein d'ELLIADD est aujourd'hui proposé à la commercialisation par l'entreprise Allucyne <https://www.allucyne.com/en/our-immersive-solutions/>. Mme Boivin-Delpieu, enseignante-chercheuse au laboratoire ELLIADD et porteuse du projet Terra3D a été recrutée au 1^{er} octobre 2021 par l'entreprise Allucyne pour son département recherche & développement.

