

INFORMATIQUE ET SANTÉ : L'EXEMPLE DE LA PSYCHIATRIE NUMÉRIQUE

HISTOIRE D'UN RENDEZ-VOUS MANQUÉ

Vincent P. MARTIN

14 mars 2023

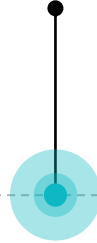
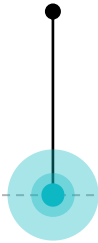
PLAN DE LA PRÉSENTATION

**Informatique et
psychiatrie**

**Et les
utilisateurs ?**

**Un outil
objectif ?**

**Symptômes :
perspectives**



1.

Informatique et psychiatrie

AVANT DE COMMENCER

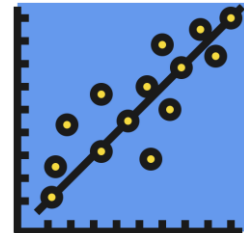
PSYCHIATRIE : DE QUOI PARLE-T-ON ?

- ▶ “the branch of medicine concerned with the study, diagnosis, and treatment of mental illness.” Oxford dictionary
- ▶ Entretien clinique → Symptômes et syndromes → Diagnostic → Schéma thérapeutique
- ▶ Psychiatrie ≠ Psychologie ≠ Psychanalyse ≠ Psychothérapie

AVANT DE COMMENCER

INFORMATIQUE, STATISTIQUES, IA ?

- ▶ l'intelligence artificielle représente tout outil utilisé par une machine afin de « **reproduire des comportements liés aux humains**, tels que le raisonnement, la planification et la créativité » (CNIL)
- ▶ « Artificial Intelligence and Statistics: Just the Old Wine in New Wineskins? » Faes et al. 2022



Un peu d'histoire



INFORMATIQUE ET PSYCHIATRIE

DE NOMBREUSES MODALITÉS

► Texte : Eliza (1966)

Welcome to

EEEEEE	LL	IIII	ZZZZZZ	AAAAA
EE	LL	II	ZZ	AA AA
EEEEEE	LL	II	ZZZ	AAAAAAA
EE	LL	II	ZZ	AA AA
EEEEEE	LLLLLL	IIII	ZZZZZZ	AA AA

Eliza is a mock Rogerian psychotherapist.
The original program was described by Joseph Weizenbaum in 1966.
This implementation by Norbert Landsteiner 2005.

ELIZA: Is something troubling you ?
YOU: Men are all alike.
ELIZA: What is the connection, do you suppose ?
YOU: They're always bugging us about something or other.
ELIZA: Can you think of a specific example ?
YOU: Well, my boyfriend made me come here.
ELIZA: Is it important to you that your boyfriend made you come here ?
YOU: He says I'm depressed much of the time.
ELIZA: I am sorry to hear that you are depressed.
YOU: It's true. I am unhappy.
ELIZA: Can you explain what made you unhappy ?
YOU:

INFORMATIQUE ET PSYCHIATRIE DE NOMBREUSES MODALITÉS

- Texte : Eliza (1966)
- Analyses biologiques (MRI, analyse sanguine)
- Analyses génétiques
- Prédiction et classification (1950's)
- ...

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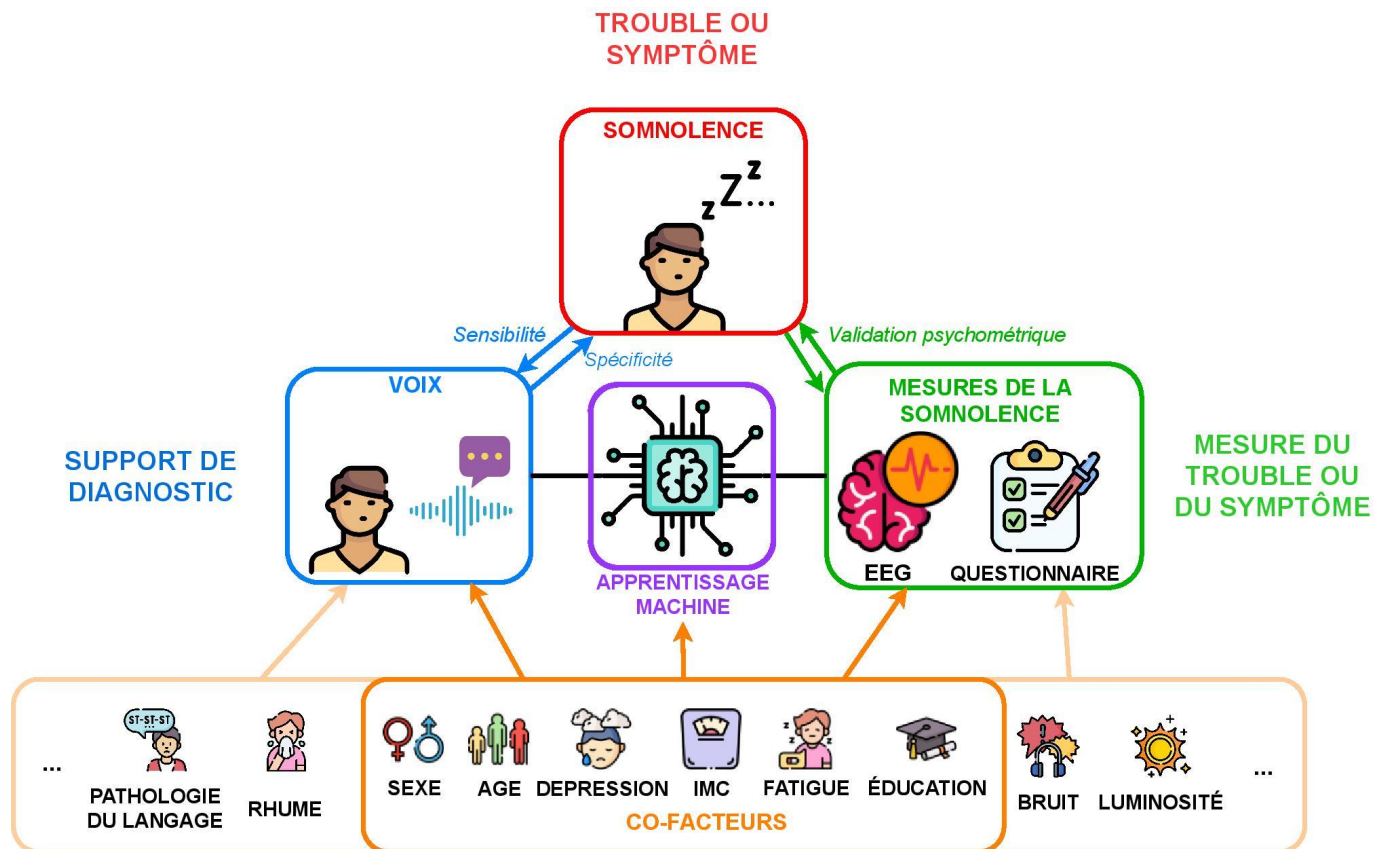
ASPECTS HISTORIQUES



- ▶ Meehl (1920-2003)
- ▶ 1957 : Clinical vs. Statistical prediction
- ▶ 1964 « the clinician performs certain unique, important, and unduplicable functions, in some of which he has literally no competition »
- ▶ « A therapist cannot put his patient in cold storage while he, the therapist, runs off a P-technique factor analysis on a 28-variable correlation matrix derived from the patient's verbal productions during the preceding 30 minutes. [...] the time required for coding and feeding would make this science fiction fantasy an inadequate solution. »

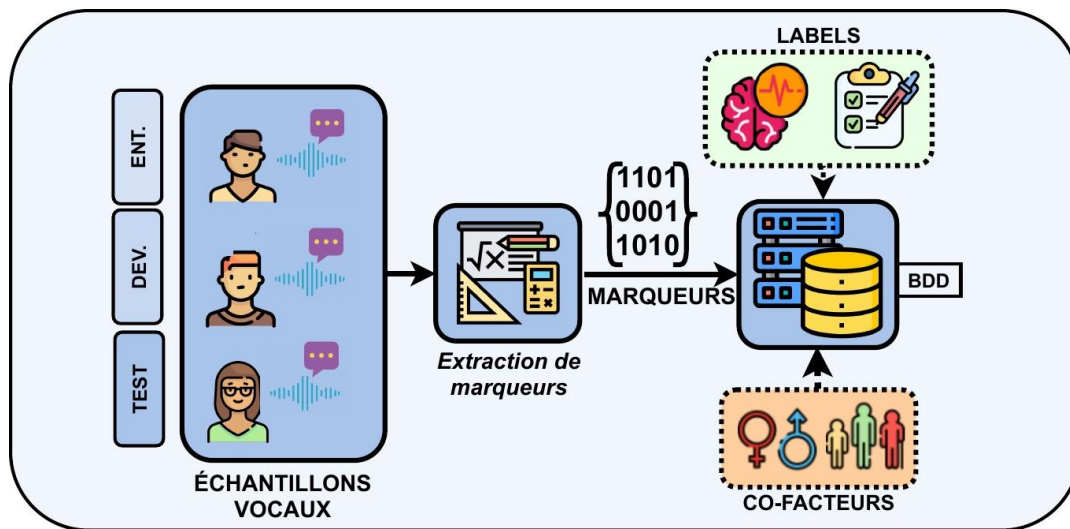
INFORMATIQUE ET PSYCHIATRIE

EX : LES BIOMARQUEURS VOCAUX



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EX : LES BIOMARQUEURS VOCAUX

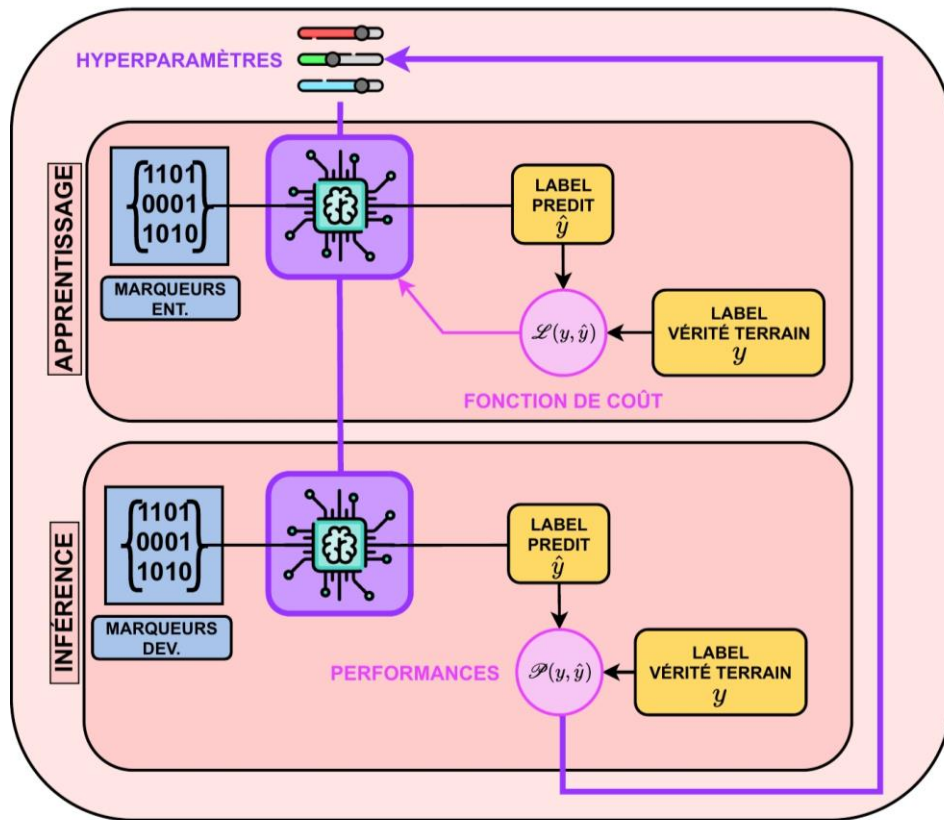


1

ÉLABORATION DE LA BASE
DE DONNÉES

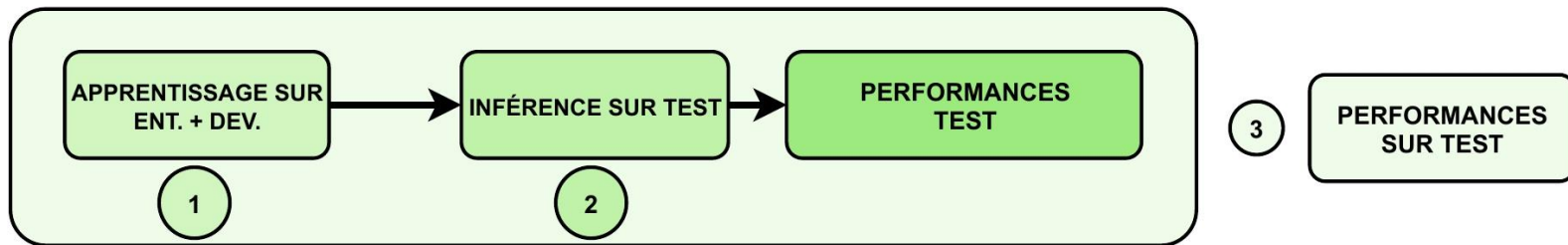
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EX : LES BIOMARQUEURS VOCAUX



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EX : LES BIOMARQUEURS VOCAUX



État de l'art



INFORMATIQUE ET PSYCHIATRIE

BIOMARQUEURS VOCAUX : ÉTAT DE L'ART

- [Low et al. 2020](#),
« Automated assessment of
psychiatric disorders using
speech: A systematic review »,
*Laryngoscope Investigative
Otolaryngology*



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BIOMARQUEURS VOCAUX : ÉTAT DE L'ART

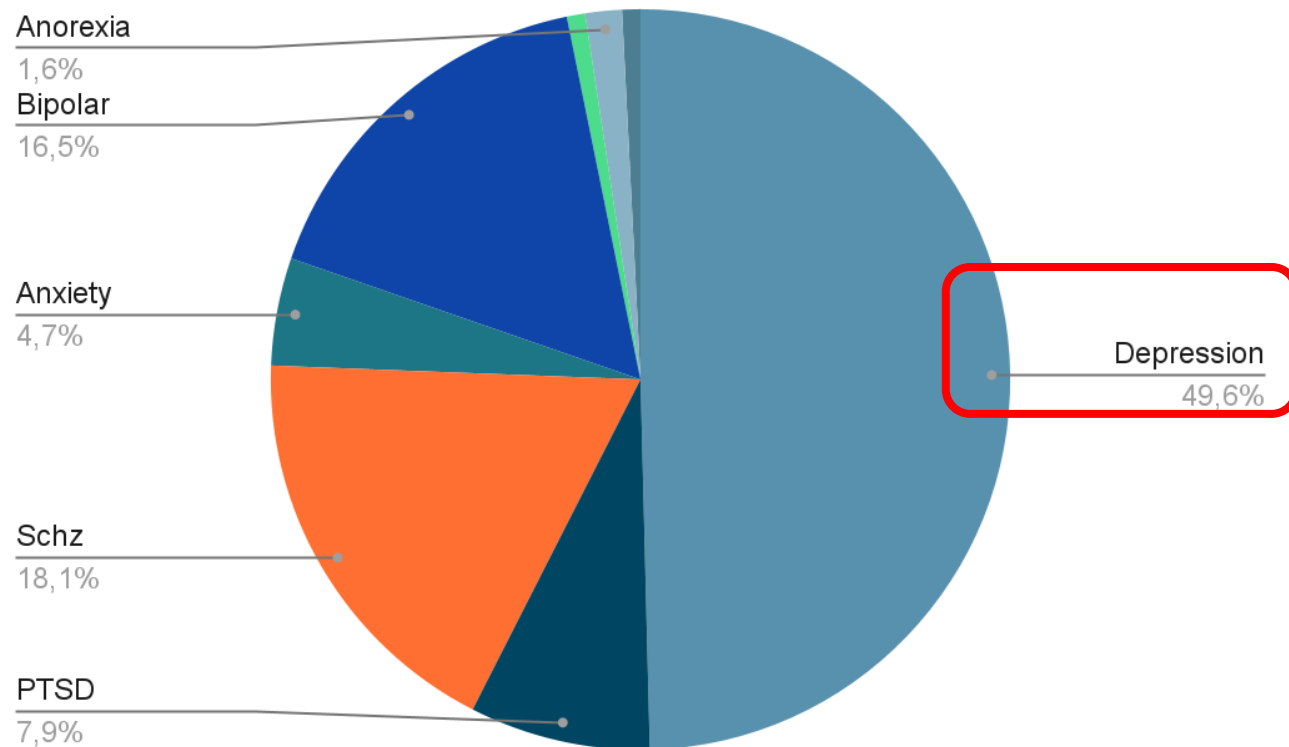
- Google Scholar
- 2009-2019

▸ **127** études

Données supplémentaires
en ligne

INFORMATIQUE ET PSYCHIATRIE

BIOMARQUEURS VOCAUX : ÉTAT DE L'ART



2.

Un outil objectif ?

UN OUTIL OBJECTIF ?

LE BESOIN DE DIAGNOSTICS OBJECTIFS

“There is an **urgency** to **objectively diagnose**, monitor over time, and provide evidence-based interventions for individuals with mental illnesses”

Low et al. 2020

“Gold-standard diagnostic and assessment tools for depression and suicidality remain rooted, almost exclusively, on the **opinion of individual clinicians** risking a range of **subjective biases**. [...] Currently there is no **objective measure**, with **clinical utility**, for either depression or suicidality”

Cummins et al. 2015

UN OUTIL OBJECTIF ?

LE BESOIN DE DIAGNOSTICS OBJECTIFS

Aboraya 2007

- ▶ 28 professionnels de santé
- ▶ La plupart d'entre eux/elles (87%) : leur diagnostic = pas fiable
- ▶ Pourquoi ?
 - ▶ Définition des maladies: **14.9%**
 - ▶ Caractéristiques des patients: **21.6%**
 - ▶ Facteurs liés aux cliniciens (éducation, biais, style) : **63.5%**

1er facteur impliqué dans le diagnostic = clinicien

UN OUTIL OBJECTIF ?

LE BESOIN DE DIAGNOSTICS OBJECTIFS

Kendell 1971

Table 6.—Diagnoses Given to Patient F		
	American Psychiatrists (N = 133)	British Psychiatrists (N = 194)
Schizophrenia	92 (69%)	4 (2%)
Simple	0	1
Catatonic	1	0
Paranoid	27	1
Latent	8	0
Residual	3	0
Schizo-affective	33	1
Unspecified	20	1
Personality Disorder	10 (8%)	146 (75%)
Paranoid	1	2
Affective (cyclothymic)	1	8
Explosive	0	2
Hysterical	4	105
Asthenic	0	2
Antisocial	1	8
Unspecified	3	19
Affective Psychosis	10 (8%)	7 (4%)
Neurosis	19 (14%)	37 (19%)
Alcoholism or Drug Dependence	2	0

⇒ Nous avons besoin de
diagnostics **objectifs**

Diagnostic : de quoi parle-t-on ?



UN OUTIL OBJECTIF

DIAGNOSTIC : DE QUOI PARLE-T-ON ?

Annotation des bases de données

- Questionnaires (ex. PHQ9)

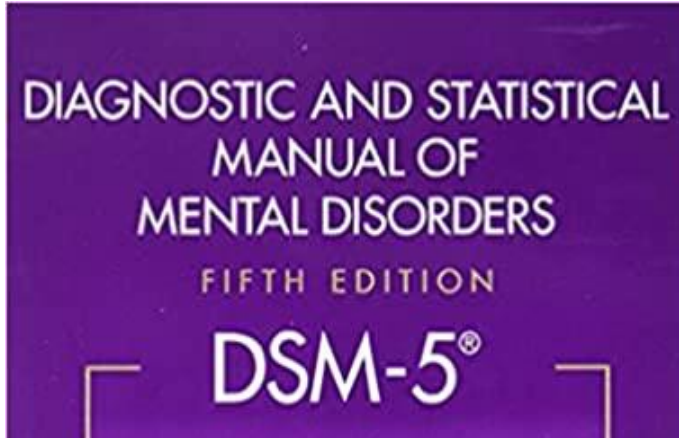
		Not at all	Several days	More than half the days	Nearly every day
1.	Little interest or pleasure in doing things	0	1	2	3
2.	Feeling down, depressed, or hopeless	0	1	2	3
3.	Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4.	Feeling tired or having little energy	0	1	2	3
5.	Poor appetite or overeating	0	1	2	3
6.	Feeling bad about yourself — or that you are a failure or have let yourself or your family down	0	1	2	3
7.	Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8.	Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9.	Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

UN OUTIL OBJECTIF

DIAGNOSTIC : DE QUOI PARLE-T-ON ?

Label

- ▶ Questionnaires (ex. PHQ9)
- ▶ Classifications de référence
(par ex. DSM or ICD)



Major Depressive Disorder

Diagnostic Criteria

- A. Five (or more) of the following symptoms have been present during the same 2-week period and represent a change from previous functioning; at least one of the symptoms is either (1) depressed mood or (2) loss of interest or pleasure.

Note: Do not include symptoms that are clearly attributable to another medical condition.

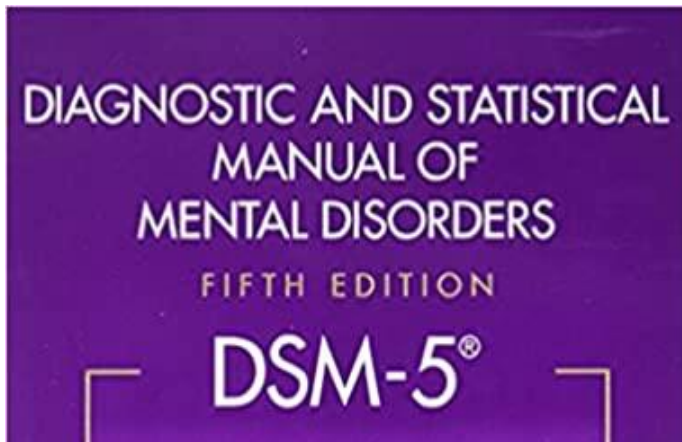
1. Depressed mood most of the day, nearly every day, as indicated by either subjective report (e.g., feels sad, empty, hopeless) or observation made by others (e.g., appears tearful). (**Note:** In children and adolescents, can be irritable mood.)
2. Markedly diminished interest or pleasure in all, or almost all, activities most of the day, nearly every day (as indicated by either subjective account or observation).
3. Significant weight loss when not dieting or weight gain (e.g., a change of more than 5% of body weight in a month), or decrease or increase in appetite nearly every day. (**Note:** In children, consider failure to make expected weight gain.)
4. Insomnia or hypersomnia nearly every day.
5. Psychomotor agitation or retardation nearly every day (observable by others, not merely subjective feelings of restlessness or being slowed down).
6. Fatigue or loss of energy nearly every day.
7. Feelings of worthlessness or excessive or inappropriate guilt (which may be delusional) nearly every day (not merely self-reproach or guilt about being sick).
8. Diminished ability to think or concentrate, or indecisiveness, nearly every day (either by subjective account or as observed by others).
9. Recurrent thoughts of death (not just fear of dying), recurrent suicidal ideation without a specific plan, or a suicide attempt or a specific plan for committing suicide.

UN OUTIL OBJECTIF

DIAGNOSTIC : DE QUOI PARLE-T-ON ?

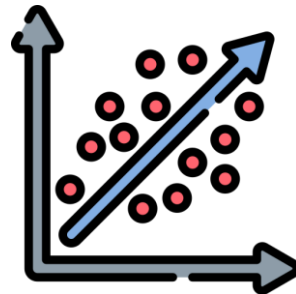
Label

- ▶ Questionnaires (ex. PHQ9)
- ▶ Classifications de référence (par ex. DSM or ICD)



Tâches d'apprentissage automatique

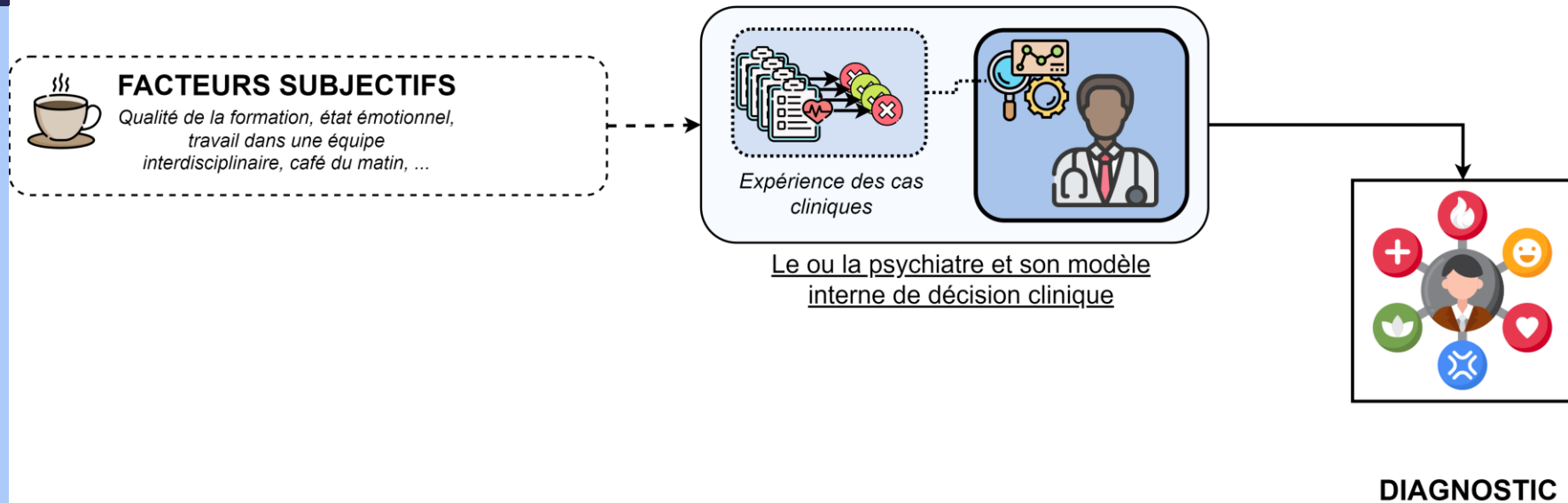
- ▶ **diagnostic**: classification binaire
- ▶ **estimation de la sévérité**: régression avec le score



Qu'est ce qu'un
diagnostic « objectif » ?

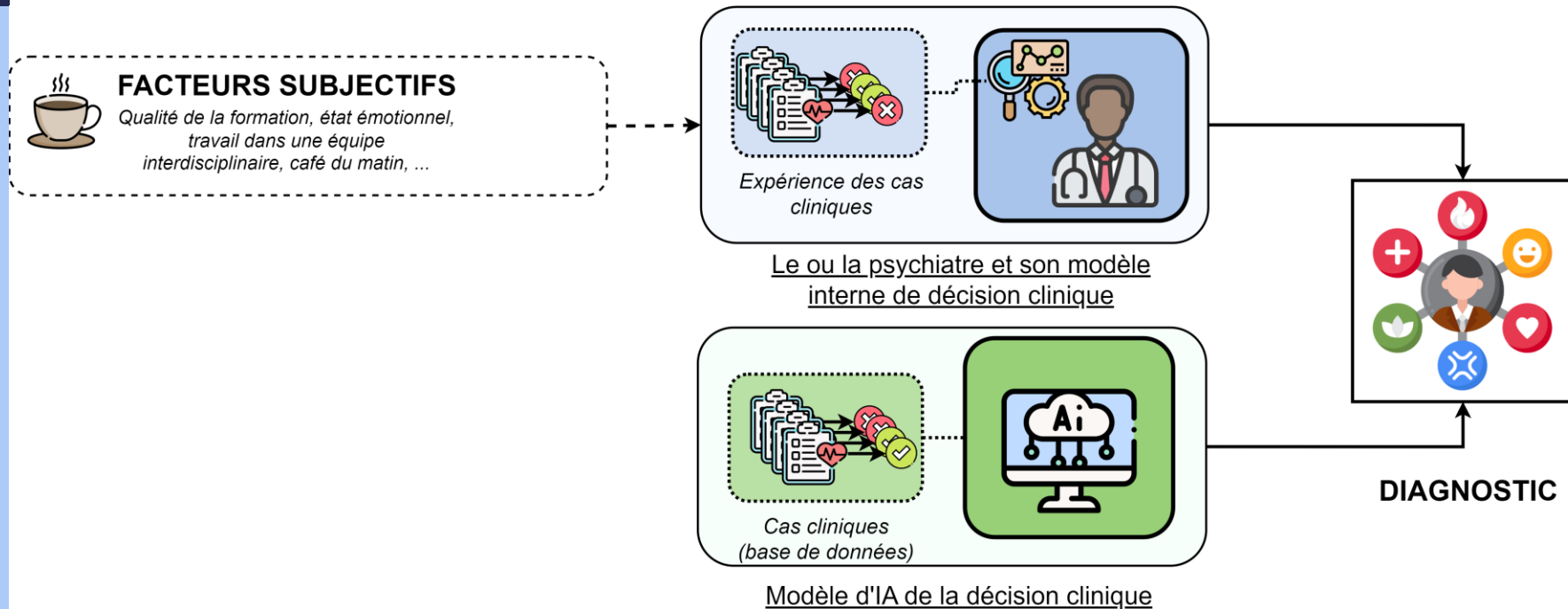
UN OUTIL OBJECTIF

QU'EST-CE QU'UN DIAGNOSTIC OBJECTIF ?



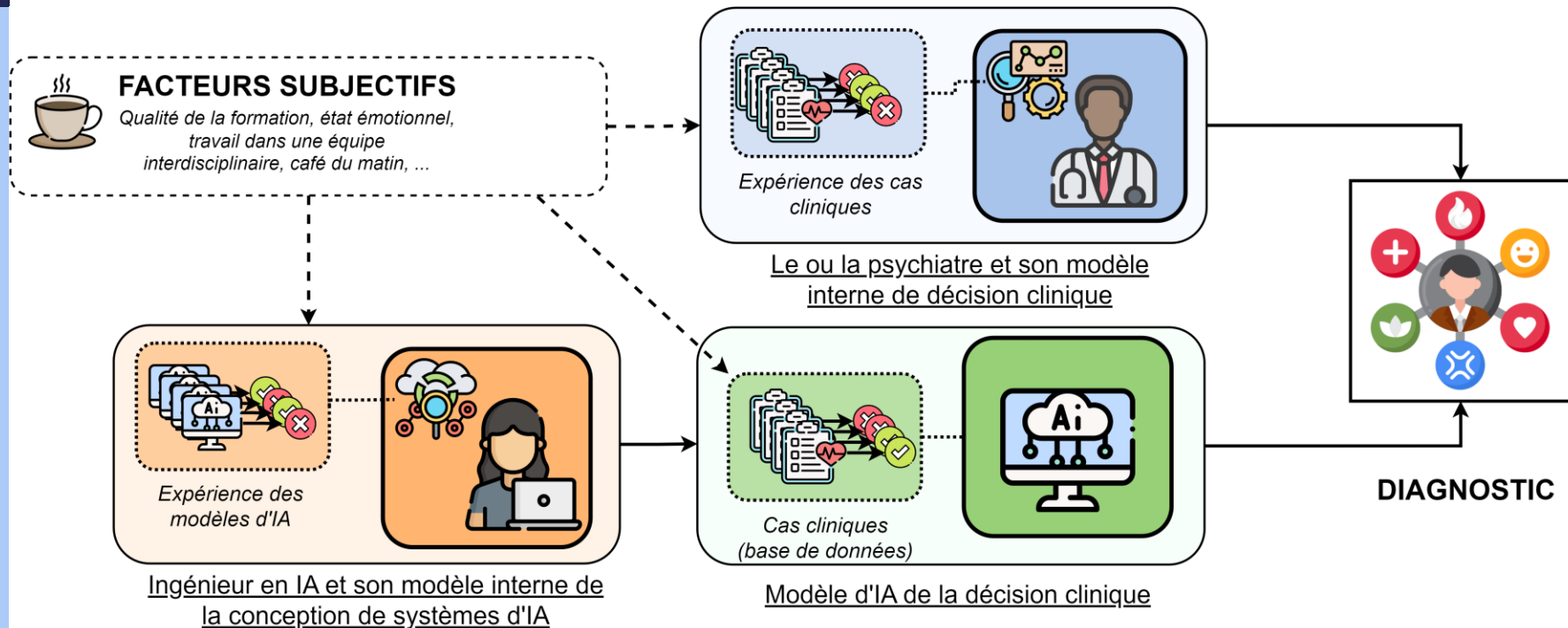
UN OUTIL OBJECTIF

QU'EST-CE QU'UN DIAGNOSTIC OBJECTIF ?



UN OUTIL OBJECTIF

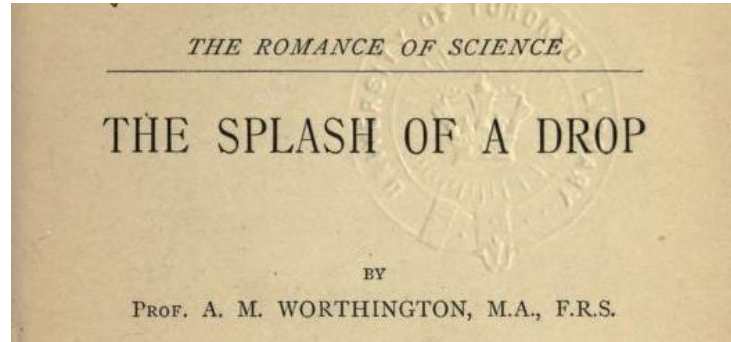
QU'EST-CE QU'UN DIAGNOSTIC OBJECTIF ?



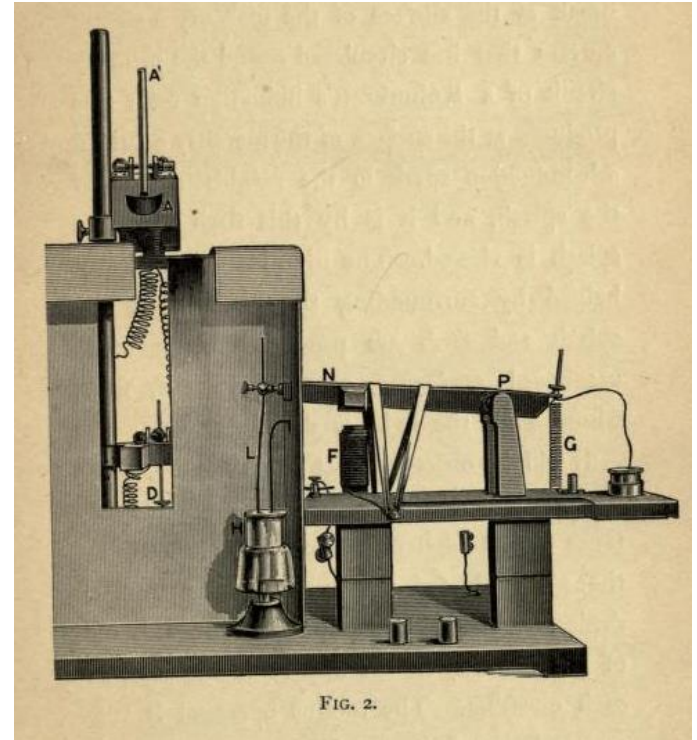
UN OUTIL OBJECTIF EST-CE QUE «OBJECTIF», C'EST MIEUX ?

THE SPLASH OF A DROP,

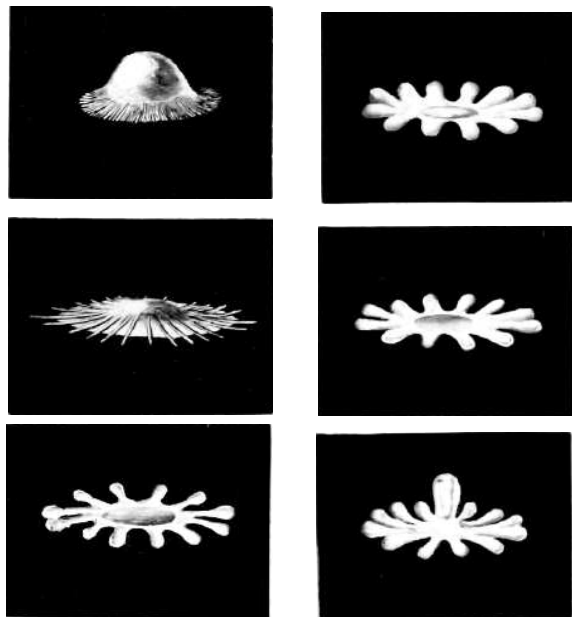
Pr. Worthington, *Royal Institution of Great Britain*, May 18, 1894



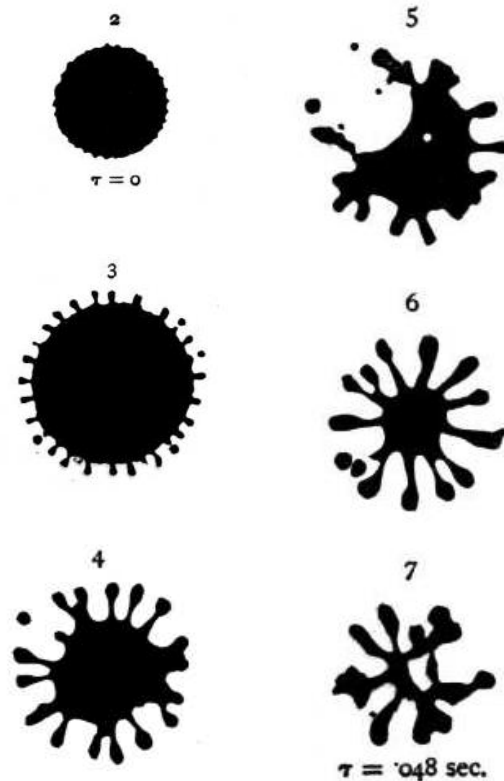
- ▶ Goutte de mercure sur du verre
- ▶ Lumière à délais constants



UN OUTIL OBJECTIF EST-CE QUE «OBJECTIF», C'EST MIEUX ?



Lequel représente **le mieux** la réalité ?





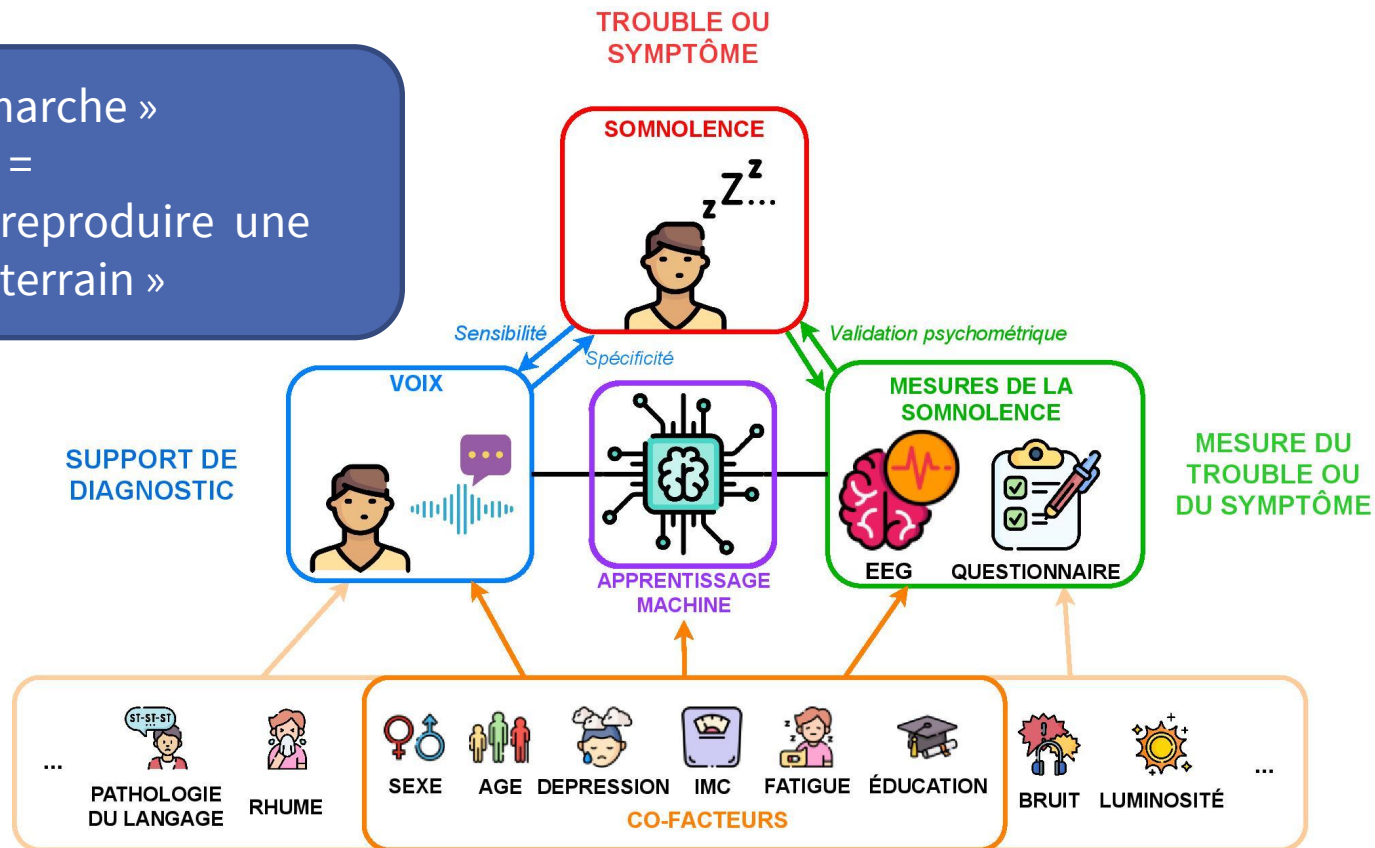
« Mais ça marche ! »

« MAIS ÇA MARCHE ! » ÇA MARCHE ?

« Ça marche »

=

« On arrive à reproduire une
vérité terrain »



« MAIS ÇA MARCHE ! » ADVERSARIAL ATTACKS



"Panda"

57.7% de confiance

+ .007 ×



Bruit

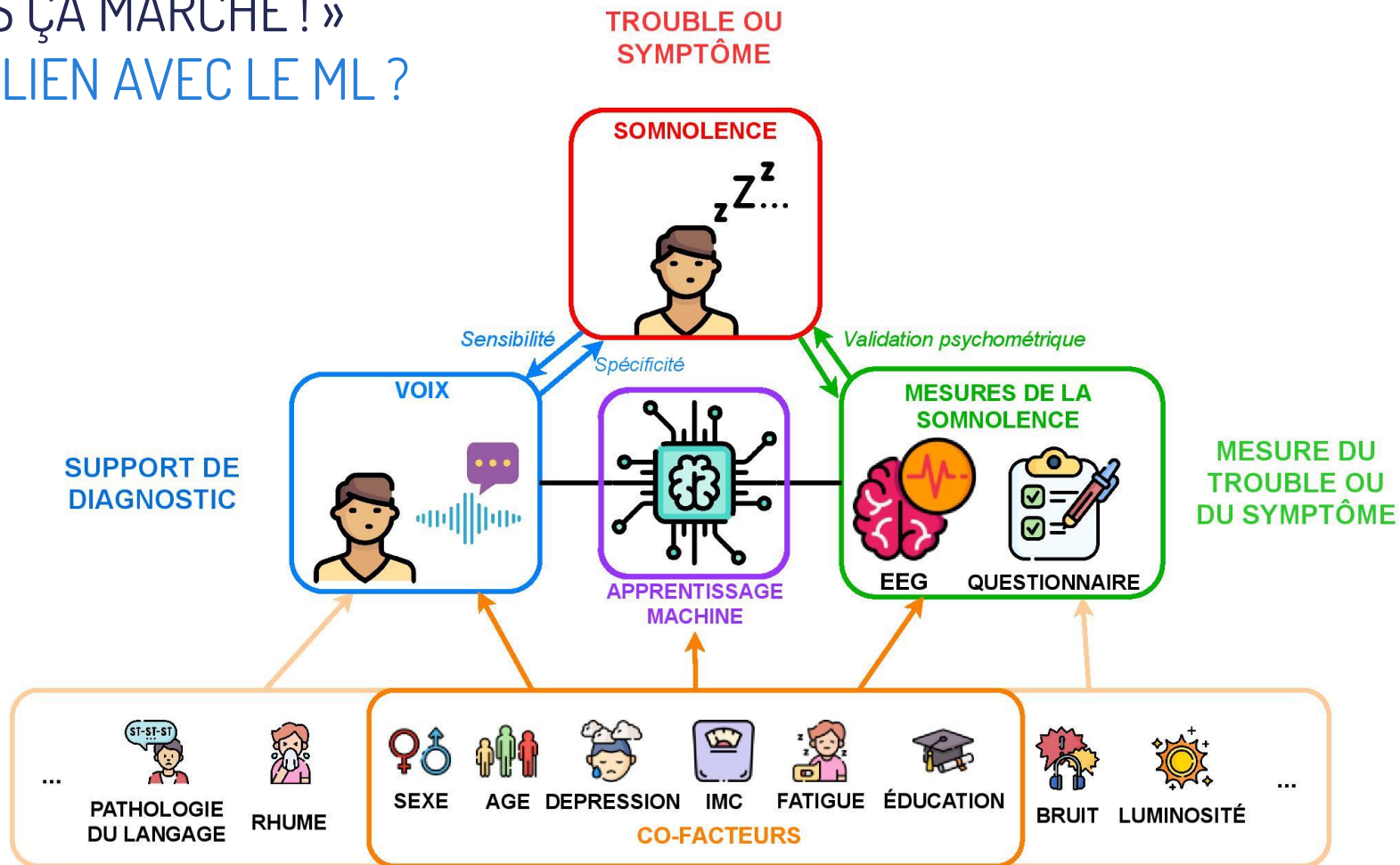
« MAIS ÇA MARCHE ! »

HANS LE MALIN, OU L'EFFET PYGMALION

- ▶ Le cheval du Dr. Von Osten (Pfungst,1911)



« MAIS ÇA MARCHE ! » QUEL LIEN AVEC LE ML ?



« MAIS ÇA MARCHE ! »
IRRELEVANT TRANSFORMATIONS

Solution ?
Irrelevant transformations

Sturm 2014

3.

Et les utilisateurs ?

**Pb : non utilisés dans les
conditions cliniques réelles**


ET LES UTILISATEURS ?

POURQUOI N'EST-CE PAS ENCORE UTILISÉ ?

- ▶ Performances ?
 - ▶ **80%** pour le trouble bipolaire, **95%** pour la schizophrénie, **89.3%** pour la dépression
 - ▶ Bonnes performances depuis des décennies (e.g. 75% for depression en 2013)





ET LES UTILISATEURS ? POURQUOI N'EST-CE PAS ENCORE UTILISÉ ?

- ▶ Performances ? 
- ▶ Taille des bases de données ?
 - ▶ Bases de données enregistrées en condition écologique
 - ♦ n=9920 ([Rutowski et al. 2022](#))
 - ♦ n=3580 ([Di et al. 2021](#))






ET LES UTILISATEURS ? POURQUOI N'EST-CE PAS ENCORE UTILISÉ ?

- Performances ? 
- Bases de données ? 
- Limites réglementaires ?



ET LES UTILISATEURS ?

POURQUOI N'EST-CE PAS ENCORE UTILISÉ ?

- Performances ? 
- Bases de données ? 
- Limites réglementaires ? 
- Transparence ?
 - **CONFIANCE**



ET LES UTILISATEURS ? POURQUOI N'EST-CE PAS ENCORE UTILISÉ ?

- Performances ? ❌
- Bases de données ? ❌
- Limites réglementaires ? ❌
- Transparence ? ❌



ET LES UTILISATEURS ? RELATION THÉRAPEUTIQUE



► **Bourla et al.:** *Bourla et al. 2018*

- 515 psychiatres
- 3 scénarios: bracelet connecté pour le phénotypage numérique, tests sanguins analysés par ML, magnetic resonance imaging (MRI) analyse avec ML.
- 4 domaines : utilité, utilisabilité, fiabilité, risque

- Acceptabilité globale = moyenne.
- **Tous les systèmes = risqués (410/515, 79.6%).**
- Acceptabilité = Très influence par caractéristiques socioepidemiologiques culture professionnelle, sexe, age, approche théorique.
- **Inquiétudes =**
 - ◆ Sécurité des données, stockage des données, risqué liés à la privacité
 - ◆ **Relation thérapeutique**

ET LES UTILISATEURS ? RELATION THÉRAPEUTIQUE

Bourla et al. 2018

- Importante pour le traitement et l'issue thérapeutique
- « Vous êtes dépressif », « Vous avez sûrement une schizophrénie », ...
= Utile ni pour les cliniciens, ni pour les patients

+ limites conceptuelles des critères diagnostiques

Limites des critères diagnostiques

ET LES UTILISATEURS ?

LIMITES DES CRITÈRES DIAGNOSTIQUES

Questionnaires

- Non utilisés par les cliniciens
- Validés sur les critères diagnostiques

Critères diagnostiques

- Culture (hikikomori)
- Temps (versions of the DSM)
- **Hétérogénéité**

ET LES UTILISATEURS ?

LIMITES DES CRITÈRES DIAGNOSTIQUES

Dépression

- ▶ Nombre de profils symptomatiques
- ▶ $n = \binom{2}{1} \times \left(\binom{8}{4} + \binom{8}{5} + \dots + \binom{8}{8} \right)$
- ▶ = **326 profils uniques**
- ▶ **Eiko Fried:** [STAR*D \(2015\)](#) : 1030 profils sur 3703 patients “dépressifs”



Major Depressive Disorder

Diagnostic Criteria

- A. Five (or more) of the following symptoms have been present during the same 2-week period and represent a change from previous functioning; at least one of the symptoms is either (1) depressed mood or (2) loss of interest or pleasure.
- Note:** Do not include symptoms that are clearly attributable to another medical condition.
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ET LES UTILISATEURS ?

LIMITES DES CRITÈRES DIAGNOSTIQUES

Newson 2021

- ▶ **107349** patients
- ▶ **10** troubles les plus prévalents
- ▶ **47** symptômes

- ▶ Conclusion : « DSM-5 disorder criteria **do not separate individuals from random** when the complete mental health symptom profile of an individual is considered.»

ET LES UTILISATEURS ?

LIMITES DES CRITÈRES DIAGNOSTIQUES

Questionnaires

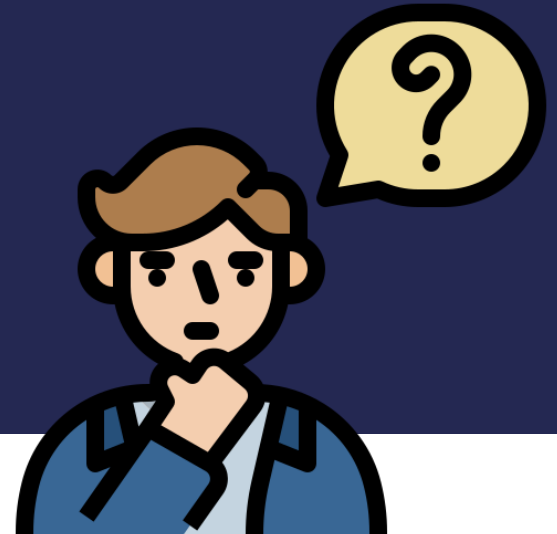
- Non utilisés par les cliniciens
- Validés sur les critères diagnostiques

Critères diagnostiques

- Culture (hikikomori)
- Temps (versions of the DSM)
- Hétérogénéité

Schéma thérapeutique = transdiagnostic

Donc le diagnostic est
inutile ?



ET LES UTILISATEURS ?

RÔLE DU DIAGNOSTIC

“the main aim of the psychiatric science **is not classification** as an end in itself but rather **identification of causes** and **interventions**”

Keneth Kendler, 2012

“[...] **classification in itself is** less important than often supposed to be, and **less important than other tasks.**”

Derek Bolton, 2012

« [...] one of its most important goal is to **facilitate communication among clinicians, researchers, administrators and patients** [...] by establishing a common language.”

Derek Bolton, 2012

- + **pronostic**
- + **diagnostic différentiel**

QUE FAIRE ?

Symptômes

3.

Symptômes : perspectives

SYMPTÔMES : PERSPECTIVES DIAGNOSTIC VS. SYMPTÔMES

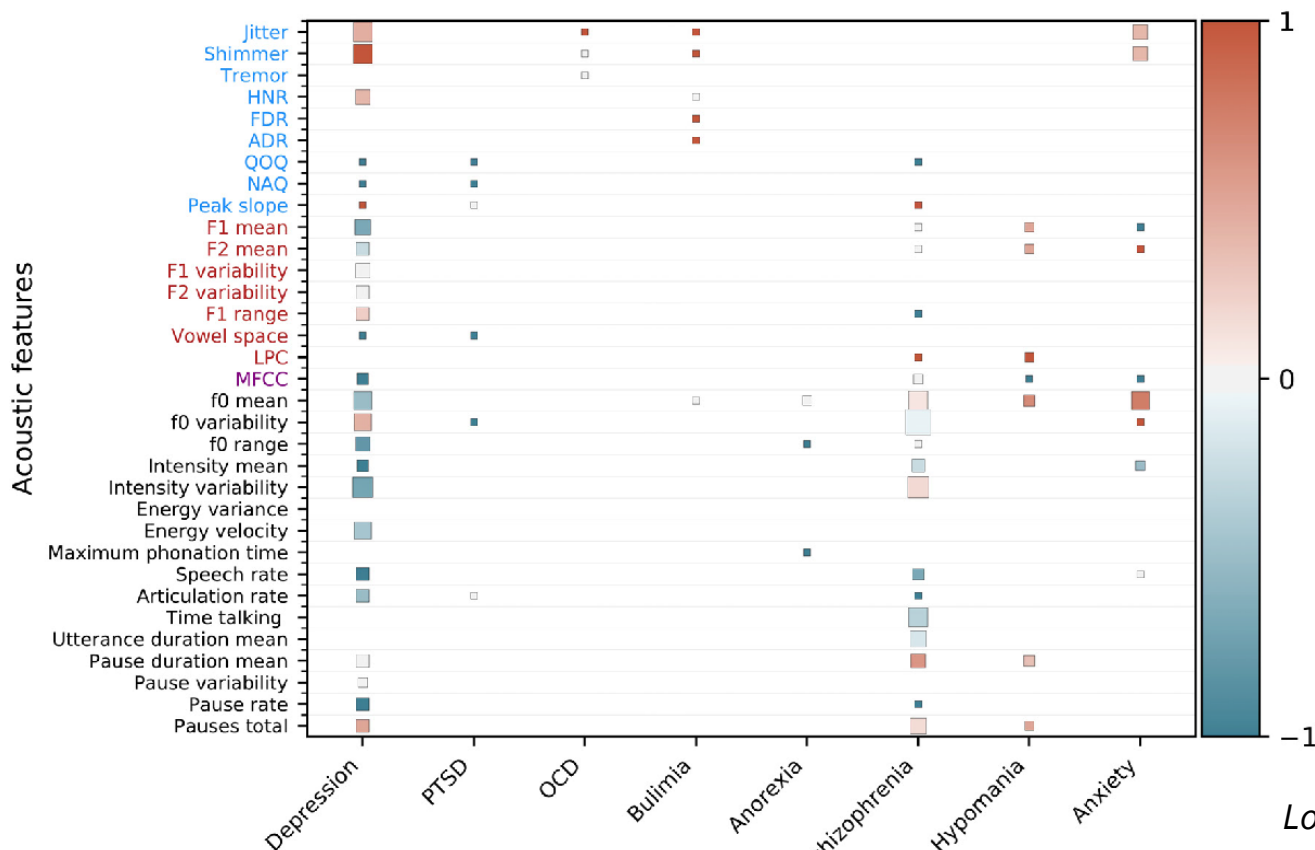
Diagnostic

Symptômes



SYMPTÔMES : PERSPECTIVES

BIOMARQUEURS : SPÉCIFICITÉ



SYMPTÔMES : PERSPECTIVES DIAGNOSTIC VS. SYMPTÔMES



Diagnostic	Symptômes
Dépendance temporelle <i>e.g. DSM IV, DSM 5, ...</i>	Stable à travers le temps
Dépendance à la culture <i>e.g. Hikikomori</i>	Indépendant de la culture
Hétérogène	Homogène
Symptômes → Syndromes → Diagnostic	
-	Explication mécanistique



SYMPTÔMES : PERSPECTIVES DIAGNOSTIC VS. SYMPTÔMES



Diagnostic	Symptômes
Dépendance temporelle <i>e.g. DSM IV, DSM 5, ...</i>	Stable à travers le temps
Dépendance à la culture <i>e.g. Hikikomori</i>	Indépendant de la culture
Hétérogène	Homogène
Symptômes → Syndromes → Diagnostic	
-	Explication mécanistique
-	Nécessaire pour le diag. différentiel et le pronostic



Mieux que les symptômes ?
Les symptômes numériques

SYMPTÔMES : PERSPECTIVES

SYMPTÔMES NUMÉRIQUES

“subjects have no need to be equipped with multiple sensors or even be burdened by **invasive devices** (e.g., endoscopy) [...] Additionally, CA can make it feasible to collect data from subjects via mobile devices (e.g., a smartphone), which can provide the subjects **24×7 monitoring service**.”

Qian et al. 2020



- + Pas de jugement
- + Facile d'accès (smartphones)
- + **Pas de biais (patients and clinicians)**

SYMPTÔMES : PERSPECTIVES

SYMPTÔMES NUMÉRIQUES

Mouchabac et al. 2021

Anchoring bias	Tendency to focus on a first impression or on the first information received to form an opinion about a number, a person, an event ... This judgmental bias can prevent important information received later to be taken into account.
Ascertainment	Tendency to selectively analyse clinical data in the light of prior expectations or beliefs (belief bias). This bias can impact the interpretation of new information resulting from precise surveillance or screening of certain symptoms.
Availability bias	Tendency to form an opinion based on the most recent and readily available information in one's mind, considered more likely. For example, for an opinion on a treatment, we remember the last few patients rather than a series of 100.
Base-rate neglect	Type of error due to poor knowledge of disease incidence rates, either by underestimating or by overestimating the occurrence of a diagnosis.
Confirmation bias	Tendency to select and interpret information confirming a clinical intuition or a priori diagnosis, and to neglect information that contradicts or invalidates this intuition.
Diagnosis momentum	Diagnosis or treatment plans established by previous clinicians are rarely questioned by new practitioners and stick to the patient. This phenomenon can prevent considering new options and enhancing the diagnosis or provided healthcare.
Illusory correlation	Tendency to infer causation relationships between correlated but independent events.
Premature closure	Tendency to stop reasoning, evaluating or looking for a better diagnosis or treatment alternative after finding a suitable enough option (close to 'satisfaction search bias').
Primacy effect	Mnemonic bias, tendency to remember and consider more the first information out of a list of equal importance.
Recency effect	Mnemonic bias, tendency to remember and consider more the most recent information (received last), for example the last words of a clinical interview or the last symptoms of a list.
Unpacking principle bias	Type of error occurring when not all the necessary information were requested to make an objective judgement. The risk would be, for example, to omit information that would allow a differential diagnosis.
Affect bias	When decisions are made in a context where the immediate emotions are strong and can influence our choices.
Ambiguity or risk aversion	Type of bias describing the tendency to favour choices with known risks and associated probabilities rather than ambiguous or uncertain options.
Commission bias	Tendency to favour action over inaction, even when inaction would be more rational. It can result in overprescription.
Default bias or status quo bias	Tendency to stick to the default option and avoid changes. The cost of change in terms of cognitive effort is automatically considered too great and one continues to behave in the same way.
Framing bias	The perception of a situation can be influenced by the way options are being presented (formulation with different numerical presentations, or with positive or negative connotations...).
Information bias	This bias translates into errors in the collection of information, for example during an interview: it can be a failure to observe, a misclassification or organisation of data, or errors in memory recall during synthesis.
Loss aversion	Tendency to be more sensitive to the loss of a certain amount of resources (cognitive effort, time, money ...) than to the gain of the same amount of resources, resulting in choices that tend to avoid losses rather than attempt gain.

Omission bias	Tendency to favour inaction or to avoid difficult issues over action ('wait and see'). It affects self-doubting clinicians.
Outcome bias	Tendency to focus on the outcome of the decision rather than the information to be interpreted to make a relevant decision. This bias is more common among clinicians with lower self-confidence and can lead to an incorrect diagnosis.
Representativeness restraint bias	Tendency to rely on the 'frequency argument,' i.e., to favour the most common hypotheses and not to mention the rarer ones. It is a restriction of thought that prevents a broader questioning of a clinical situation.
Retrospective prejudice	When the result of a situation is known, it can influence the way in which we perceive the preceding events as we forget the uncertainty we were facing at that time, and lead to fallacious reconstruction ('we are remaking history'). It can prevent learning and lead to the repetition of error.
Self-served bias	Tendency to reduce the analysis of clinical data and the diagnosis to one's own point of view. It affects communication between the different parties (physician, patients, and other stakeholders).
Sunk cost fallacy	Tendency, when one has already invested a lot of resources (time, energy or money) in a project or an action that seems to have little chance of succeeding, to continue investing although it is doomed to failure. In medicine, it is a question of pursuing an ineffective strategy, for example.
Bandwagon effect	Tendency to conform and reproduce a behaviour or an attitude just to act as others do.
Fundamental attribution error	While making judgments about people's behaviour, it's the tendency to overemphasise dispositional factors or personality-based explanations and underestimate situational ones. The consequence is the risk of making incorrect judgments, discounting reasons that might have contributed to their observed behaviour.
Stereotyping	Tendency to infer characteristics about an individual based on the group in which we categorised him/her. This can result in a wrong diagnosis solely based on our belief that the patient belongs to a certain group with a typical disease.

SYMPTÔMES : PERSPECTIVES

SYMPTÔMES NUMÉRIQUES

“subjects have no need to be equipped with multiple sensors or even be burdened by **invasive devices** (e.g., endoscopy) [...] Additionally, CA can make it feasible to collect data from subjects via mobile devices (e.g., a smartphone), which can provide the subjects **24×7 monitoring service**.”

Qian et al. 2020



- + Pas de jugement
- + Facile d'accès (smartphones)
- + **Pas de biais (patients and clinicians)**

SYMPTÔMES : PERSPECTIVES

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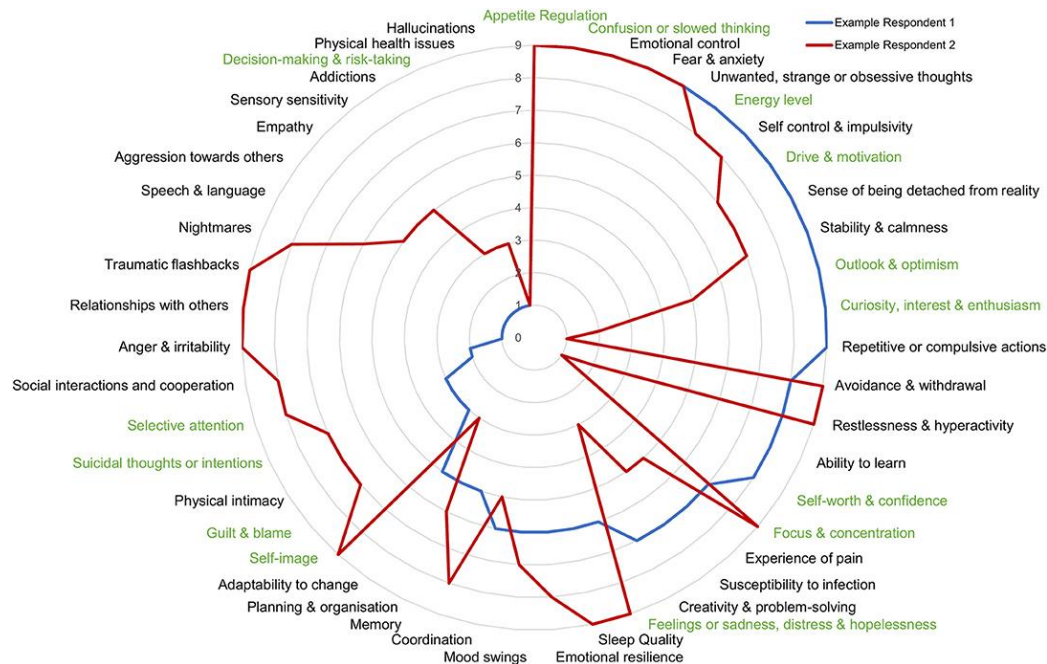
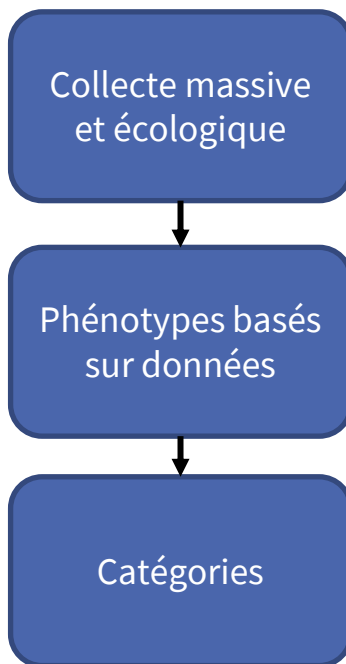
Qian et al. 2020



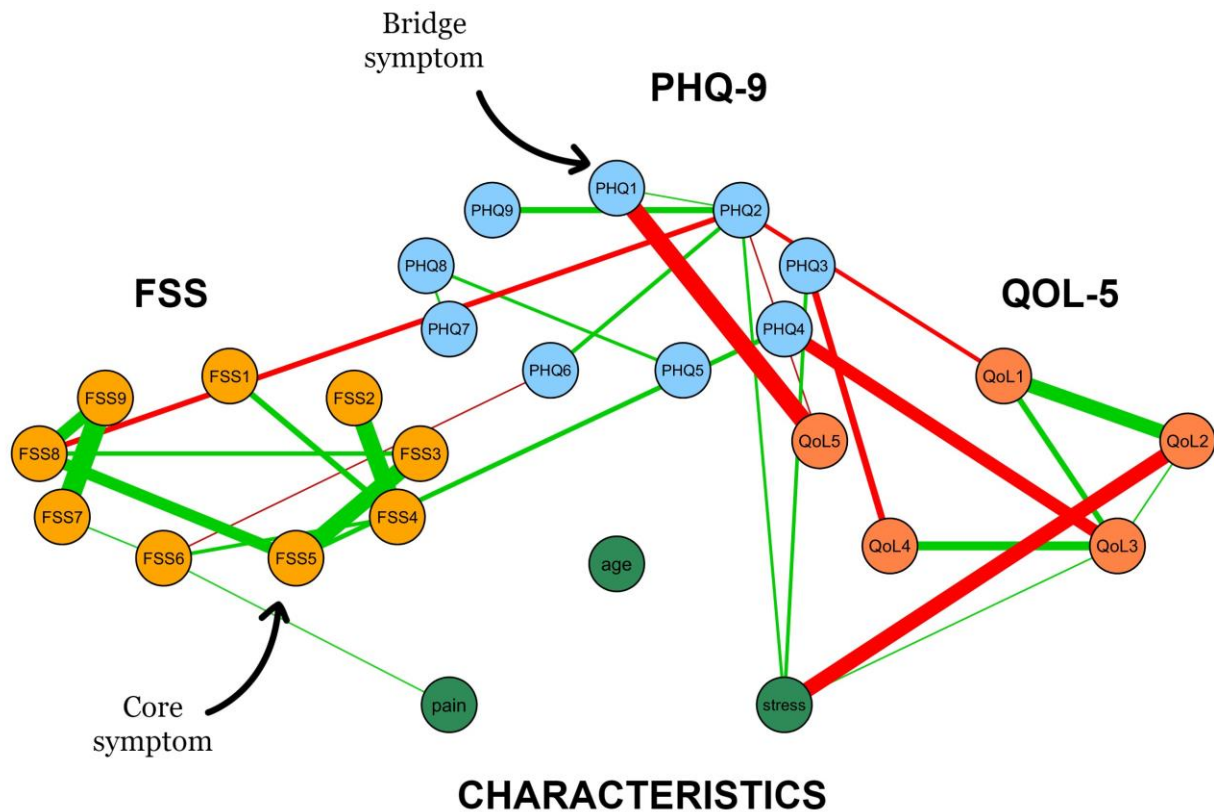
- + Pas de jugement
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- + **Injustices épistémiques**

SYMPTÔMES : PERSPECTIVES SYMPTÔMES NUMÉRIQUES

Médecine stratifiée

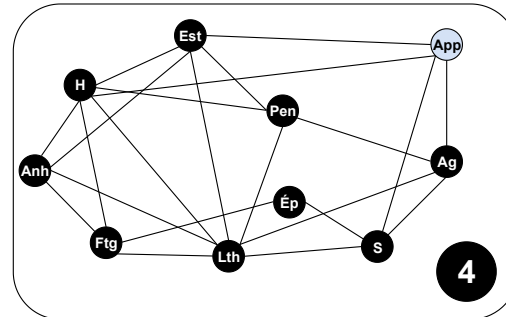
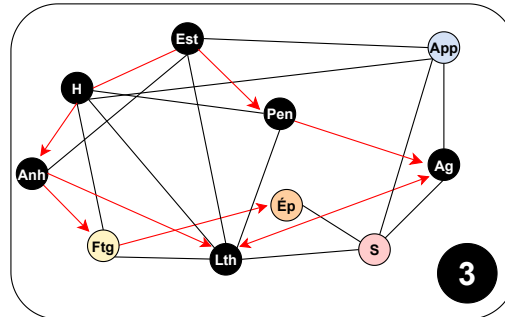
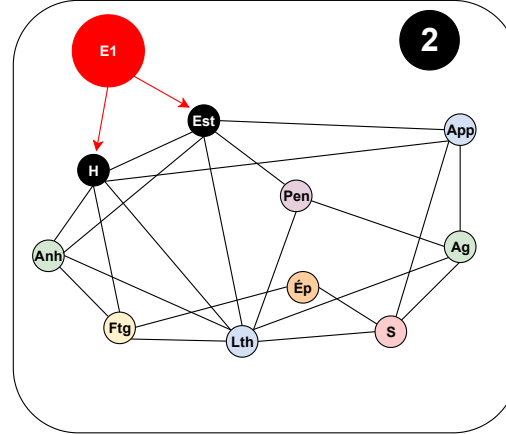
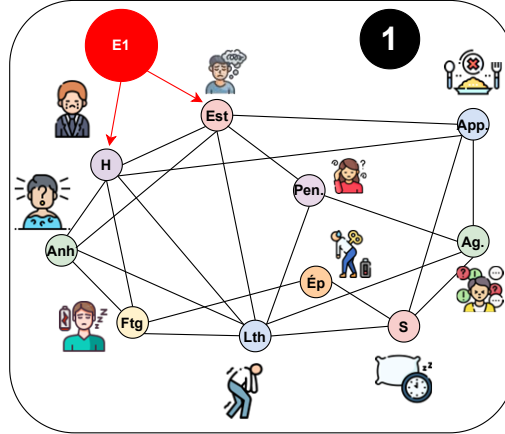


Nouveaux modèles des troubles : les réseaux de symptômes



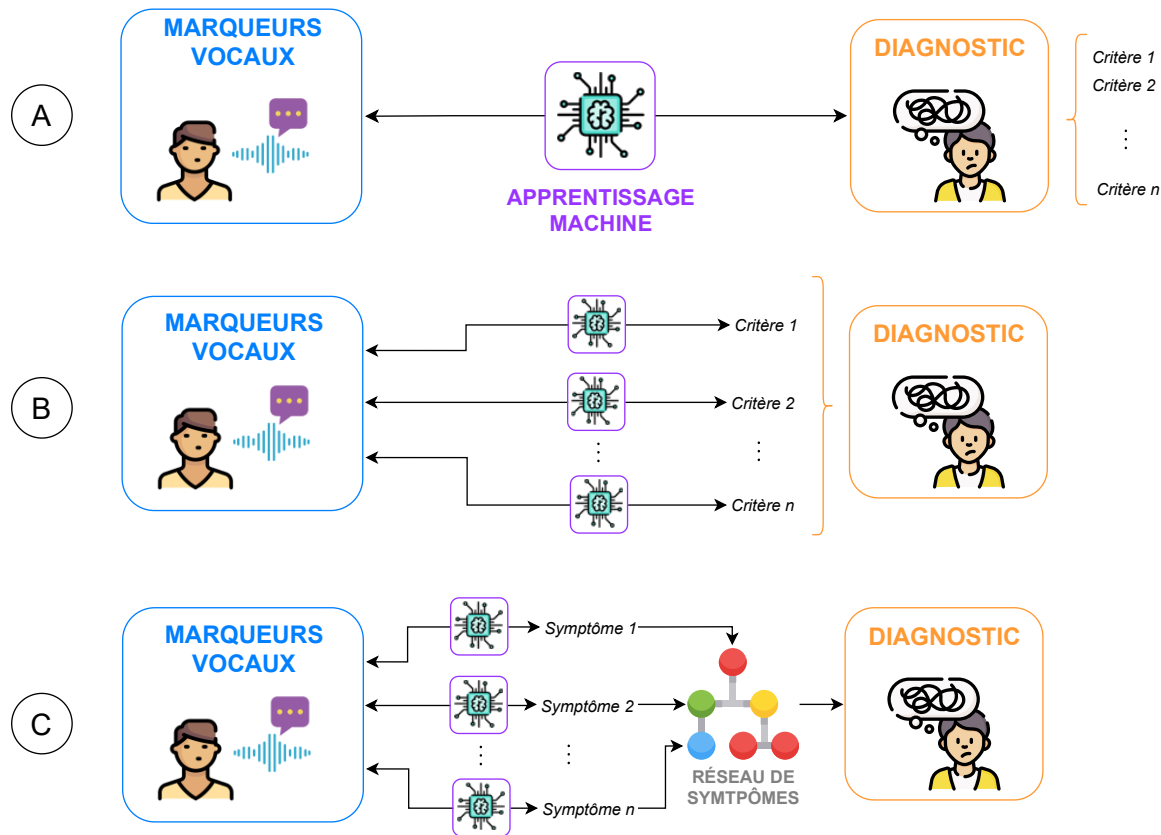
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RÉSEAUX DE SYMPTÔMES



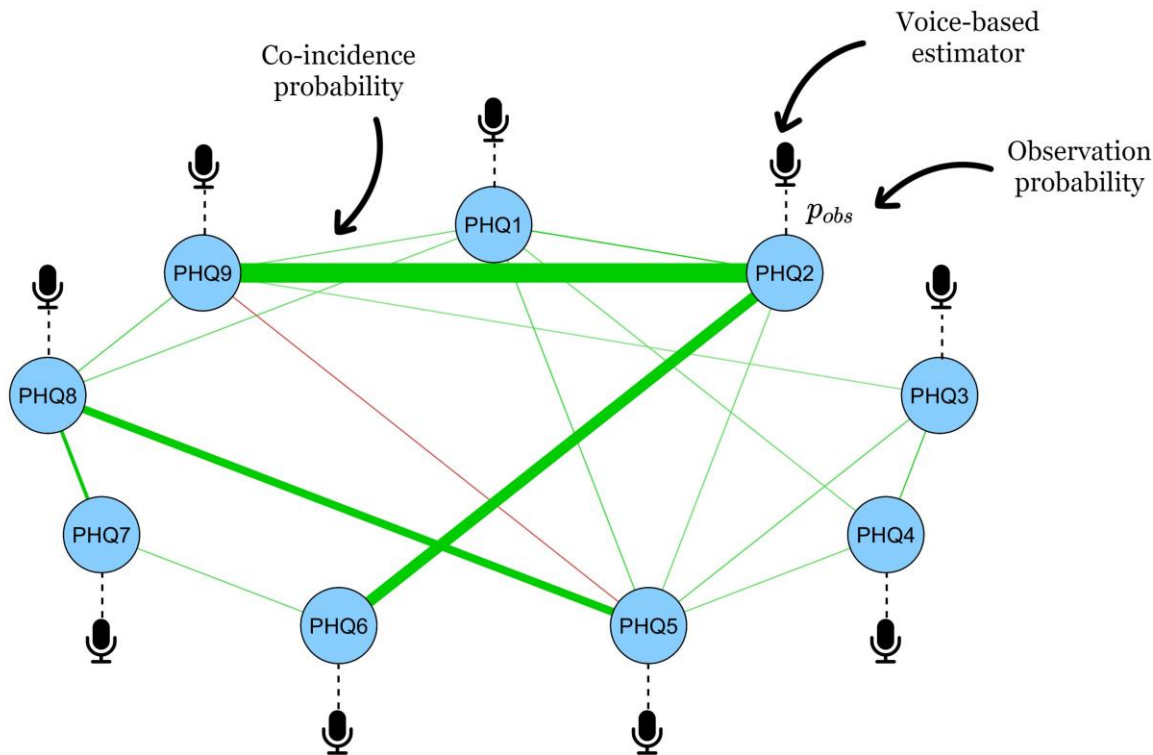
SYMPTÔMES : PERSPECTIVES

RÉSEAUX DE SYMPTÔMES



SYMPTÔMES : PERSPECTIVES

RÉSEAUX DE SYMPTÔMES



Conclusion

Doggy bag

DOGGY BAG

- Informatique très prometteuse en psychiatrie
- **MAIS** avant les développement technologiques, écoute et compréhension des utilisateurs
- Attention aux systèmes “objectifs”

Merci de votre
attention!

QUESTIONS?



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Vincent-P-Martin