An alternative terminology for pain assessment

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***Abstract* — Background: the International Association for the Study of Pain (IASP) publishes since 1986 a relatively frequently updated list of pain terms with corresponding definitions and clarificatory notes currently known as the 'IASP Taxonomy'. The last update, i.e. the May 2012 version of this taxonomy, was subjected to an analysis with the goal to assess whether the definitions of the IASP terms that are used to describe findings of somatosensory testing and pain assessment satisfy the conditions for these terms to become part of a realism-based ontology. Results: the taxonomy was found to be built on definitions that are not in every case based on necessary and sufficient conditions, nor satisfy the single inheritance principle for realism-based ontologies. Furthermore, although the documentation about introduced changes provided by the IASP makes it clear that the terminology authors tried to solve ambiguities and unclarities present in previous versions, they did not succeed completely and introduced even some inconsistencies. The analysis demonstrates that the main cause for this is not the choice of differentiating characteristics, but rather insufficient attention to the wide variability in stimulus/response combinations that these characteristics reveal. Conclusions: the IASP taxonomy is not fit to form the basis for a realism-based ontology. A new representation framework for describing pain assessment findings more accurately using the same set of differentiae is proposed and its correspondence with the traditional terminology explained.**

Keywords—pain terminology, ontological realism

I. BACKGROUND

The Ontology for Pain-Related Mental Health and Quality of Life (OPMQoL) is being developed as part of the NIDCR-funded project R01DE021917 with the goal to integrate five datasets gathered in four different countries from patients suffering from one or other form of orofacial pain [1, 2]. Part of the data in these datasets describe findings that are based on the various kinds of responses that patients may report when subjected to stimuli to test their somatosensory status and that are typically described using terms such as 'allodynia', 'hyperesthesia', and so forth. Although these terms were already in practice since at least the early 19th century [3], standard definitions for these terms were first proposed in 1979 [4] and are since then regularly updated by the International Association for the Study of Pain (IASP), in print for the last time in 1994 [5], with more regular electronic updates on the IASP webpage [6] the last one in May 2012 (Table 1). These definitions are further based on the IASP definition for '*pain'* as '*an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage*'.

For terms to be eligible as representational units in a realism-based ontology such as OPMQoL, they must not only (1) denote entities that can be classified following the principles of Ontological Realism [7], but also (2) be defined using Aristotelian definitions which specify the necessary and sufficient conditions for class membership, and further lead to a taxonomy based on single inheritance [8]. The goal of the work reported on here was to assess the adherence of the IASP pain assessment definitions to this second condition and to find ways for remediation if non-compliance was found.

Allodynia: pain due to a stimulus that does not normally provoke pain. Note: The stimulus leads to an unexpectedly painful response.
Analgesia: absence of pain in response to stimulation which would normally be painful.
Dysesthesia: an unpleasant abnormal sensation, whether spontaneous or evoked. Note: Special cases of dysesthesia include hyperalgesia and allodynia.
Hyperalgesia: increased pain from a stimulus that normally provokes pain.
Hyperesthesia: increased sensitivity to stimulation, excluding the special senses.
Hyperpathia: a painful syndrome characterized by an abnormally painful reaction to a stimulus.
Hypoalgesia: diminished pain in response to a normally painful stimulus.
Hypoesthesia: decreased sensitivity to stimulation, excluding the special senses.
Paresthesia: an abnormal sensation, whether spontaneous or evoked. Note: paresthesia is to be used to describe an abnormal sensation that is not unpleasant.

Table 1 - Pain terms analyzed

II. METHODS

Based on the definitions of the terms studied – note that table 1 contains only part of the relevant notes and that the reader should for complete understanding of the analysis method consult reference [6] - an analysis framework was designed by introducing nine hierarchically organized variables reflecting the type of stimulus, the presence or absence of a response, and the type of response when present, when a patient is subjected to a pain assessment investigation. The allowed values for these variables were defined, depending on what the variable stands for, either on a nominal or ordinal scale (Table 2).

Variable	Values
Stimulus application	Y(es)
modus M level Threshold	B(elow), O(n), A(bove)
Pain level Threshold	B(elow), O(n), A(bove)
Response to stimulus	Y(es), N(o)
modus M Response	Y(es), N(o)
modus M Intensity	L(ess), C(oncordant), H(igh)
Unpleasant response	Y(es), N(o)
Pain Response	Y(es), N(o)
Pain Intensity	L(ess), C(oncordant), H(igh)

Table 2 - Basic analysis framework variables, values and definitions

The next step consisted of identifying and representing all theoretically possible stimulus/response combinations, a part of which is displayed in Table 3.

Although the maximal theoretical number of possible combinations would be 1296 (1*3*3*2*2*3*2*2*3), the actual number is only 130 because of the hierarchical organization of the variables which implements the following dependencies typical for somatosensory and pain assessment studies [9]:

1. each stimulus, whether to test either somatosensory status (e.g. temperature, pressure, pin prick, and so forth, henceforth called 'modus M') or pain sensitivity, falls under one of three disjoint categories: (1) below threshold, (2) on threshold, or (3) above threshold;
2. modus M and pain stimuli may be given selectively or together, thus resulting in 4 stimulation modes: (1) sub-threshold (for both pain and modus M), (2-3) modus M- or pain-selective, and (4) bimodal (i.e. on or supra-threshold for both modus M and pain);
3. if there is no response to a stimulus, then there are no values for the intensity of modus M sensation and pain;
4. if a response is present, it may be either (4a) selective, i.e. exclusively being unpleasant, painful, or of modus M in isolation, or (4b) combining either a modus M and non-painful unpleasant response, or a modus M and painful response;
5. all pain responses are unpleasant, thus following the IASP definition for '*pain'* as '*an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage*', but an unpleasant response does not need to be painful.

As a third step, each combination was assessed for whether it could figure as an exemplar for each of the terms of Table 1. Table 4 provides an example of this step for the IASP-definition of 'allodynia' without taking the note into account. A complication at this phase was that the definitions and notes left certain questions with respect to inclusion and exclusion criteria unanswered. It was thus for many definitions required to find meaningful subgroups and for some of these subgroups the IASP documentation did not provide enough information to assess whether they represent intended interpretations, although from a terminological and ontological perspective perfectly plausible. Table 5 shows the subgroups identified as well as the counts of stimulus/response combinations that fall under them. When subgroups were defined, the count for the (direct or indirect) parent terms were obtained by applying a Boolean OR operation on the combinations (and not the mere addition as subgroups are not necessarily mutually exclusive). This information was in a fourth step used to compute the exact overlap between these terms in function of positive and negative co-occurrence.

S	**Stimulus given**	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
MT	**Modus M threshold**	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PT	**Pain Threshold**	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
R	**Response**	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
MR	**Modus M response**	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
MI	**Modus M response Intensity**	-	-	-	-	-	L	L	L	L	L	C	C	C	C	C	H	H	H	H	H
U	**Unpleasant response**	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y
PR	**Pain Response**	-	N	Y	Y	Y	-	N	Y	Y	Y	-	N	Y	Y	Y	-	N	Y	Y	Y
PI	**Pain Response Intensity**	-	-	L	C	H	-	-	L	C	H	-	-	L	C	H	-	-	L	C	H

Table 3 - Different stimulus/response combinations possible for bimodal above (but not 'on') threshold stimulation. Legend for values: Y = Yes, N = No, B = Below threshold stimulus, O = On threshold stimulus, A = Above threshold stimulus, H = Higher than expected response intensity, C = response intensity Concordant with stimulus, L = Lower than expected response intensity.

S	**Stimulus given**	Y	Y	Y	Y	Y	Y	Y	Y	Y
MT	**Modus M threshold**	B	B	O	O	O	O	A	A	A	A
PT	**Pain Threshold**	B	B	B	B	B	B	B	B	B	B
R	**Response**	Y	Y	Y	Y	Y	Y	Y	Y	Y
MR	**Modus M response**	N	Y	N	Y	Y	Y	N	Y	Y	Y
MI	**Modus M response Intensity**	-	H	-	L	C	H	-	L	C	H
U	**Unpleasant response**	Y	Y	Y	Y	Y	Y	Y	Y	Y
PR	**Pain Response**	Y	Y	Y	Y	Y	Y	Y	Y	Y
PI	**Pain Response Intensity**	H	H	H	H	H	H	H	H	H	H
ALLO-D		Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 4 - Possible stimulus/response combinations for Allodynia (following the IASP definition strictly). Legend for values: Y = Yes, N = No, B = Below threshold stimulus, O = On threshold stimulus, A = Above threshold stimulus, H = Higher than expected response intensity, C = response intensity Concordant with stimulus, L = Lower than expected response intensity.

Acronym	Term (plus meaning)	N
CONC	Normal case	9
ALLO-D	**allodynia (definition)**: unexpected evoked pain	10
ALLO-N	**allodynia (note)**: unexpected more intense evoked pain	30
ANAL	**analgesia**: unexpected absence of evoked pain	40
DYS-E	**evoked dysesthesia**	80
DYS-EP	painful evoked dysesthesia	50
DYS-EU	non-painful evoked dysesthesia	30
HYPERA	**hyperalgesia**: unexpected more intense evoked pain	20
HYPERE	**hyperesthesia** = increased sensitivity to stimulation	81
HYPERE-I	unexpected more intense evoked sensation	42
HYPERE-IP	unexpected more intense evoked pain	20
HYPERE-IM	unexpected more intense evoked modus M	26
HYPERE-P	unexpected presence of evoked sensation	49
HYPERE-PU	unexpected evoked unpleasant sensation other than pain	30
HYPERE-PP	unexpected pain	10
HYPERE-PM	unexpected modus M	13
HYPERP	**hyperpathia**	30
HYPOALG	**hypoalgesia**	20
HYPOE	**hypoesthesia** = decreased sensitivity to stimulation	58
HYPOE-P	decreased sensitivity to pain stimulation	40
HYPOE-PL	less pain to pain stimulation	20
HYPOE-PA	non painful unpleasant response to pain stimulation	20
HYPOE-M	decreased sensitivity to modus M stimulation	26
HYPOE-BI	decreased sensitivity to both kinds of stimulation	8
PAR-D-E	**evoked paresthesia (definition)**	81
PAR-D-EP	painful evoked paresthesia	30
PAR-D-EU	non-painful unpleasant evoked paresthesia	30
PAR-D-EN	non-painful not unpleasant evoked paresthesia	39
PAR-N-E	**evoked paresthesia (note)**	19

Table 5 - Terms and ontological subgroups for the IASP pain assessment terminology. Legend: N = number of stimulus/response combinations applicable (max = 130)**.**

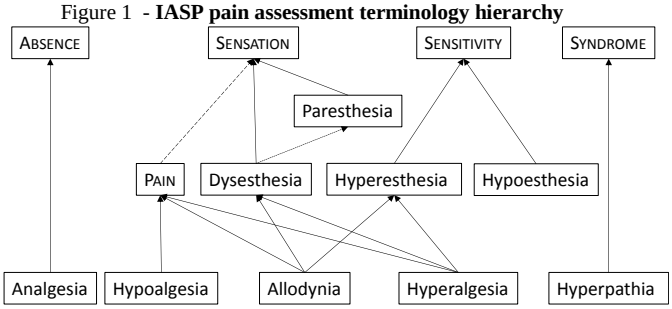
This step answers thus for each term pair 'A B' the question which and how many of the possible stimulus/response combinations can occur in the pair combinations A+/B+, A+/B-, A-/B+,A-/B- where '+' and '-' indicate that the stimulus/response combination can, resp. cannot occur under the definition of the term. As it became clear at this point that overlap was considerable, we designed a new terminology based on definitions that minimize the potential overlap using categories that are mutually exclusive. We then compared this new terminology with the traditional one, again using the stimulus/response combinations as benchmark.

III. RESULTS

A. The IASP terms do not satisfy the criteria for direct integration in a realism-based ontology.

Figure 1 - in which terms displayed in SMALL CAPS are the immediate superordinate terms found in the definitions and the arrows stand for the classical subsumption relation [10] – demonstrates that although the individual definitions follow the Aristotelian form '*an A is a B which C*', the defined terms do not lead all together to a complete directed graph with an overarching top, not even if all 29 IASP terms would be included. Furthermore, the terms '*allodynia'* and '*hyperalgesia'* have superordinate terms which under their standard meanings should represent disjoined classes: although sensation and sensitivity are certainly related,

Figure 1 - **IASP pain assessment terminology hierarchy**



nothing which **is** a kind of one can also be a kind of the other. In addition, already a superficial reading of these terms and accompanying notes reveals ambiguities and inconsistencies. The definition of '*allodynia'*, for instance, indicates that the term should be used for pain evoked after applying a stimulus which is below the normal pain threshold. The corresponding note however suggests that also a response on an above-threshold stimulus may count as such when the stimulus leads to more pain than expected. The note for '*dysesthesia'*, as many similar notes for other terms which for space reasons are not reproduced in Table 1 but can be found in reference [6], indicate that there is considerable overlap between the terms.

B. Traditional pain assessment terminology shows considerable overlap

All terms of Table 1 could be mapped to the stimulus/response combinations. Table 6 illustrates how the parent terms relate to each other in function of the stimulus/response combinations. The individual cells contain the counts for the overlap, if any. For example, the overlap cells between hyperesthesia and hypoalgesia show - surprisingly - that these two conditions do not exclude each other: 6 of the 130 combinations fall under both definitions, 14 are such that hypoalgesia is present without hyperesthesia, 75 have hyperesthesia without hypoalgesia, and 35 don't exhibit either. An additional color coding is used to highlight the type of overlap: white indicates a symmetric overlap for all 4 types of co-occurrence as exemplified by the hyperesthesia/ hypoalgesia pair; green indicates mutual exclusion of the positive occurrences, the other three colors indicate an asymmetric overlap. An ideal terminology would be such that the classes defined are mutually disjoint. For 12 (n) classes as is the case here, there are 66 possible overlaps (n*(n-1)/2) between any pair of these classes, not counting overlap of a class with itself. As displayed in Table 6, there is no overlap in only 2 cases of these 66: (1) for hyperpathia versus allodynia (taking the note into account), and (2) for hyperesthesia and paresthesia (when the note is not taken into account).

C. Novel terminology with less overlap

Table 7 provides an overview of the proposed terminology which uses 6 variables (*Response expectation*, *Main finding*, *Sensation expectation*, *Sensation intensity*, *Sensation mode*, and *Stimulation type*) that can take a number of values and which are strongly related to the variables and values used to design the analysis framework of the 130 stimulus/response combinations.

	CONC	/CONC	ALLO-D	/ALLO-D	ALLO-N	/ALLO-N	ANAL	/ANAL	DYS-E	/DYS-E	HYPERA	/HYPERA	HYPERE	/HYPERE	HYPERP	/HYPERP	HYPOALG	/HYPOALG	HYPOE	/HYPOE	PAR-D-E	/PAR-D-E	PAR-N-E	/PAR-N-E
CONC	9	0																						
/CONC	0	121																						
ALLO-D	0	10	10	0																				
/ALLO-D	9	111	0	120																				
ALLO-N	0	30	10	20	30	0																		
/ALLO-N	9	91	0	100	0	100																		
ANAL	0	40	0	40	0	40	40	0																
/ANAL	9	81	10	80	30	60	0	90																
DYS-E	0	80	10	70	30	50	20	60	80	0														
/DYS-E	9	41	0	50	0	50	20	30	0	50														
HYPERA	0	20	0	20	20	0	0	20	20	0	20	0												
/HYPERA	9	101	10	100	10	100	40	70	60	50	0	110												
HYPERE	0	81	10	71	30	51	26	55	66	15	20	61	81	0										
/HYPERE	9	40	0	49	0	49	14	35	14	35	0	49	0	49										
HYPERP	0	30	10	20	30	0	0	30	30	0	20	10	30	0	30	0								
/HYPERP	9	91	0	100	0	100	40	60	50	50	0	100	51	49	0	100								
HYPOALG	0	20	0	20	0	20	0	20	20	0	0	20	6	14	0	20	20	0						
/HYPOALG	9	101	10	100	30	80	40	70	60	50	20	90	75	35	30	80	0	110						
HYPOE	0	58	2	56	6	52	24	34	48	10	4	54	34	24	6	52	20	38	58	0				
/HYPOE	9	63	8	64	24	48	16	56	32	40	16	56	47	25	24	48	0	72	0	72				
PAR-D-E	0	81	10	71	30	51	26	55	66	15	20	61	81	0	30	51	6	75	34	47	81	0		
/PAR-D-E	9	40	0	49	0	49	14	35	14	35	0	49	0	49	0	49	14	35	24	25	0	49		
PAR-N-E	0	19	0	19	0	19	14	5	0	19	0	19	9	10	0	19	0	19	6	13	9	10	19	0
/PAR-N-E	9	102	10	101	30	81	26	85	80	31	20	91	72	39	30	81	20	91	52	59	72	39	0	111

Table 6 - Positive/negative contingency table for traditional pain terminology. A color coding is used for the 2-by-2 contingency tables to highlight the type of overlap: white indicates a symmetric overlap for all 4 types of co-occurrence; green indicates mutual exclusion of the positive occurrences, the other three colors indicate an asymmetric overlap.

	Response expectation	**Main finding**	**Sensation expectation**	**Sensation intensity**	**Sensation mode**	**Stimulation type**		
	Concordant Discordant	***Absence Presence Configuration***	***Concordant Discordant***	***hypOresponsive hypErresponsive***	***Modal Unpleasant Painful***	***Sensation***	***Subthreshold Pain-specific Modus-specific Bimodal***	***Stimulation***
CA---SS	C	A				S	S	S
DPDEMSS	D	P	D	E	M	S	S	S
DPDEUSS	D	P	D	E	U	S	S	S
DPDEPSS	D	P	D	E	P	S	S	S
DC---SS	D	C				S	S	S
CA—MSP	C	A			M	S	P	S
CPC-PSP	C	P	C		P	S	P	S
CC---SP	C	C				S	P	S
DA—PSP	D	A			P	S	P	S
DPDOUSP	D	P	D	O	U	S	P	S
DPDOPSP	D	P	D	O	P	S	P	S
DPDEMSP	D	P	D	E	M	S	P	S
DPDEPSP	D	P	D	E	P	S	P	S
DC---SP	D	C				S	P	S
CA—USM	C	A			U	S	M	S
CPC-MSM	C	P	C		M	S	M	S
CC---SM	C	C				S	M	S
DA—MSM	D	A			M	S	M	S
DPDEMSM	D	P	D	E	M	S	M	S
DPDEUSM	D	P	D	E	U	S	M	S
DPDEPSM	D	P	D	E	P	S	M	S
DC---SM	D	C				S	M	S
CPC-MSB	C	P	C		M	S	B	S
CPC-PSB	C	P	C		P	S	B	S
CC---SB	C	C				S	B	S
DA—MSB	D	A			M	S	B	S
DA—PSB	D	A			P	S	B	S
DPDOMSB	D	P	D	O	M	S	B	S
DPDOUSB	D	P	D	O	U	S	B	S
DPDOPSB	D	P	D	O	P	S	B	S
DPDEMSB	D	P	D	E	M	S	B	S
DPDEPSB	D	P	D	E	P	S	B	S
DC---SB	D	C				S	B	S

Table 7 - Proposed alternative terminology

The values for *sensation mode* are to be interpreted as follows: 'modal' means that there is only a modal response which is not unpleasant or painful, 'unpleasant' means that the response is unpleasant but not painful, irrespective of whether there is a modal response as well, whereas 'painful' means there is only a painful response. 'Subthreshold' for *stimulation type* reflects a subthreshold stimulation for both pain and modus M, while 'bimodal' indicates an above threshold stimulation for both modus M and pain.

As is the case for the analysis framework, some values are constrained by the values for some other variables. As an example, when the value for *stimulus intensity* is 'subthreshold', there is either (1) no response in which case the value for *response expectation* is constrained to 'concordant', the value for *main finding* to 'absence', and all other variables have no value, or (2) a response is present, in which case the values for *response expectation* and *sensation expectation* are both constrained to 'discordant', the value for *main finding* to 'presence', and the value for *sensation intensity* to 'hyper-responsive'. The constraints make once again the total number of possibilities lower than can be expected: 26, excluding the combinations with the value 'configuration' for main finding which are constructed by the boolean AND-ing and OR-ing of concordant and discordant situations. The terms for this terminology are then all of the form '(*Response expectation*) (*Main finding*) ***of*** (*Sensation expectation*) (*Sensation intensity*) (*Sensation mode*) ***sensation after*** (*Stimulation type*) ***stimulation***' whereby the variables in italics are replaced by the terms for the allowed values, and the words in bold are constant. As an example, the terms for the first two combinations in Table 7 are respectively 'concordant absence of sensation after subthreshold stimulation' and 'discordant presence of discordant hyper-responsive modal sensation after subthreshold stimulation'.
The left column of Table 7 contains for further reference in Table 8 acronyms for the various possibilities formed by means of the concatenation of the individual values for a certain variable, excluding, for space reasons, the last (constant) 'S' for 'Stimulation'.

Table 8 shows the extent to which the proposed terminology categories suffer from a far less degree of overlap, overlap being indicated by the cells in light and dark red background: only 23 overlaps of the total possible 325.

IV. Discussion

Our results in Table 5, combined with Table 1, clearly indicate that the traditional terminology is based on rather ambiguous definitions and application recommendations some of which lead to interpretations for which it is not clear whether they are intended or not. This is overwhelmingly obvious for the terms '*hyperesthesia'*, '*hypoesthesia'* and '*paresthesia'*. The latter is very broadly defined as an abnormal sensation, without making it explicit what '*abnormal'* exactly means: '*abnormal'* may indeed be interpreted as anything what is not expected, such as more or less intense pain than expected after giving a supra-threshold pain stimulus, or more or less intense pressure sensation than expected when giving a supra-threshold pressure stimulus.

It may also be interpreted as feeling an itch - a form of unpleasant sensation - when giving a pressure stimulus with or without there being a pressure sensation, and so forth. The note for paresthesia, in contrast, tells us that only '*not unpleasant'* sensations should count as qualifying, which limits the number of possibilities considerably.

	CA---SS	DPDEMSS	DPDEUSS	DPDEPSS	CA--MSP	CPC-PSP	DA--PSP	DPDOUSP	DPDOPSP	DPDEMSP	DPDEPSP	CA--USM	CPC-MSM	DA--MSM	DPDEMSM	DPDEUSM	DPDEPSM	CPC-MSB	CPC-PSB	DA--MSB	DA--PSB	DPDOMSB	DPDOUSB	DPDOPSB	DPDEMSB	DPDEPSB
CA---SS	1																									
DPDEMSS		1																								
DPDEUSS			2																							
DPDEPSS				2																						
CA--MSP					10																					
CPC-PSP					2	4																				
DA--PSP					4		8																			
DPDOUSP					2		4	4																		
DPDOPSP					2			4																		
DPDEMSP							2		2																	
DPDEPSP					2				4																	
CA--USM										8																
CPC-MSM										2	2															
DA--MSM										2		6														
DPDEMSM										2			2													
DPDEUSM												2		8												
DPDEPSM												2			8											
CPC-MSB																20										
CPC-PSB																4	16									
DA--MSB																	4	20								
DA--PSB																4		4	16							
DPDOMSB																			4							
DPDOUSB																4		4	16		16					
DPDOPSB																4		4			16					
DPDEMSB																					4					
DPDEPSB																4		4								

Table 8 - Overlap between proposed pain assessment categories

It leaves however still many interpretations open, such as whether the resulting sensation must be alien to the given stimulus - would an erotic feeling induced by providing a pressure stimulus to the hand count as such a non-unpleasant abnormal sensation? - or whether it may be special cases of hypo- and hyperesthesia.

These reflections provide at the same time explanations for the very high degree of overlap between the majority of the traditional terms (Table 6). There is of course a symmetric non-overlap for each category with each negation, but the only non-overlap between distinct categories is found for the pairs allodynia (taking the note into account) -hyperpathia and hyperesthesia-paresthesia (as defined, without the limiting note).

The proposed terminology shows a much more limited degree of overlap. This lesser degree of overlap is because the parameters have been chosen in such a way that a specific combination of values cannot count for a specific class in more than one way, a feature which is not exhibited by the traditional terminology.

A disadvantage of the terminology is that it is more verbose, but this is compensated by the ease by which it can be implemented in systems for structured electronic reporting and automatic assigning of the categories using single select choice lists for each variable.

V. Conclusion

It is demonstrated that the IASP terms do not satisfy the criteria for direct integration in a realism-based ontology. A new terminology for stimulus based pain and somatosensory status assessment is proposed which exhibits less shortcomings in terms of overlap than the traditional terminology. This is because in contrast to the traditional approach, this proposal does not underestimate the various stimulus/response combinations that may occur.

VI. Competing interests

None

VII. Authors' contributions

All analyses as well as paper writing were done by the author.

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