

DISCRIMINATION OF FACIAL EXPRESSIONS OF EMOTION IN ALZHEIMER PATIENTS: DISENTANGLING CRITERIA AND SENSITIVITY PARAMETERS OVER DIFFERENT FACETS OF EXPRESSION

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Abstract

Whether Alzheimer patients present a deficit in the perception of emotional expressions conveyed by faces has remained a matter of debate over the last few years. Conflicting evidence has been presented, stemming in part from methodological inadequacies in the approaches taken, in another part from lack of consideration of specific deficit hypothesis. This study aims at contributing to circumvent both shortcomings by resorting to a signal detection approach, tailored moreover to consider distinct locus of impact of such a potential deficit: upon the discrimination between 1) neutral-emotional faces; 2) emotion categories; 3) valence sign; 4) emotion intensities. Comparisons with matched groups of controls revealed similar qualitative patterns but important quantitative differences on both criteria and sensitivity indices. Sensitivity parameters calculated from intensities discrimination were shown partially dissociable from general cognitive decline and of potential diagnostic interest.

Debate over a possible deficit of Alzheimer patients concerning the discrimination of facial expressions of emotion has been plagued by a shortage of analytic considerations. For once, raw discrimination data are unclear about whether comparative differences regarding controls are due to sensitivity or response criteria parameters. Yet, given the dissimilar substantive implications of these parameters, namely to the guidance of rehabilitation programs, unravelling them would be of both theoretical as well as practical significance. Furthermore, expression and perception of emotions have been implicitly taken in most studies as unitary processes, whilst they can actually rest upon a number of distinguishable facets, such as valence, emotion type or intensity. Loosing sight of this in the planning of experiments is a highly probable source of confounding, which might account for many of the inconsistencies reported. For instance, since expression intensity, a major feature of emotion experience, is left typically uncontrolled, discrepant results could conceivably arise from particular options regarding intensity levels (for a glimpse at conflicting evidence in the literature see Allender & Kasniak, 1989; Roudier et al, 1998; Koff et al., 1999; Hargrave et al, 2002; Burnham & Hogervorst, 2004).

The present study purports to overcome both shortcomings. It uses a general same-different task with pairs of facial expressions, allowing for a signal detection analysis of the discrimination process. It extends moreover the untying of sensitivity and criterion parameters to different facets of emotional expression, by varying the dimensions along which the coupled expressions differ: emotion category, valence and intensity. For economy reasons, only three of the six discrete emotions of Ekman's taxonomy (Ekman, 1993) were considered at this time: fear, sadness, and joy.

Method

Subjects

48 Alzheimer patients (30 F, 18 M; mean age: 77 years and 8 months) recruited at the Hospital Magalhães Lemos (Oporto, Portugal) took part in the experiment. As a general proviso for inclusion, all patients fulfilled DSM-IV-TR and NINCDS-ADRDA criteria for probable Alzheimer's dementia (AD). Except for probable AD, records of severe medical pathology were taken as exclusion criteria. Forty-eight healthy elderly subjects (26 F, 22 M; mean age: 73 years and 7 months) were used as controls. As with AD patients, they were free from severe medical problems. Normal or corrected to normal levels of hearing and visual acuity were ensured for both groups and informed consent was obtained from all participants.

Stimuli

Stimuli consisted of faces selected from the databases *Pictures of Facial Affect* (Ekman et al, 1976) and *JACFEE and JACNeuF* (Matsumoto & Ekman, 1988), subsequently assembled by pairs. Pairing was of three sorts: 1) neutral face-emotional face (expressing one of three distinct emotions: joy, sadness, fear; same subject in each pair); 2) faces expressing two distinct emotions (same set of emotions as before, same subject in each pair); 3) faces expressing different degrees of intensity of a specific emotion (same set of emotions, same subject in each pair). Intensity degrees were obtained by digital morphing (with *Morpheus* software), at equal steps, between neutral expressions and maximum intensity expressions of a given emotion (according to normative ratings). Three levels of expression intensity (low, medium, high) were thus obtained for each emotion considered.

Design and Procedure

The experiment obeyed a same/different roving design embedded in a SDT framework (MacMillan & Creelman, 2005). Being the less demanding for subjects, "same-different" tasks are best suited for populations with cognitive deficits. Two separate experiments were done, with 24 AD patients and 24 controls in each. EXP I involved the *neutral-emotional* and the *emotion A-emotion B* pairs (emotion type or quality), EXP II the intensity pairs (emotion intensity). EXP II comprised furthermore three experimental blocks, one for each emotion, whose ordering was counterbalanced through a Latin-square. Overall balance between signal (different pairs) and noise (same pairs) was ensured in both experiments.

Pairs were randomly presented on a computer display (± 40 cm ahead) for 2 sec., and subjects simply asked to judge whether faces were "different" or "the same", without time limit. Beforehand, all subjects were given the MMSE (Folstein *et al.*, 1975) and the *Global Deterioration Scale* (GDS) (Reisberg *et al.*, 1988). Degree of functional efficiency was also assessed through *Barthel* (Barthel, 1965) and the *Lawton and Brody's* indices (Lawton, 1969). AD patients were moreover assessed with *B.L.A.D.* (Garcia, 1984), a battery of neuropsychological tests adapted from the *Lisbon Screening for Demential Assessment* .

Results

EXP I (Emotion Type/Quality)

Exp I involved both the «*neutral - emotion*» (N-E) and «*emotion A - emotion B*» (E-E) pairs intertwined along a total of 336 experimental trials. Figures 1 and 2 depict the patterns of

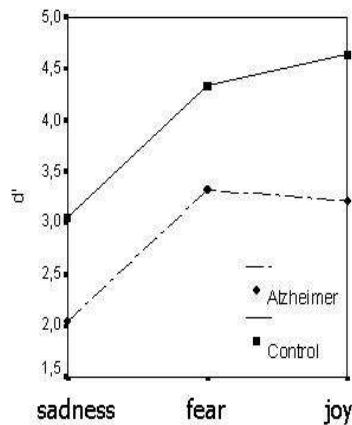


Fig.1 neutral-emotion pairs (d')

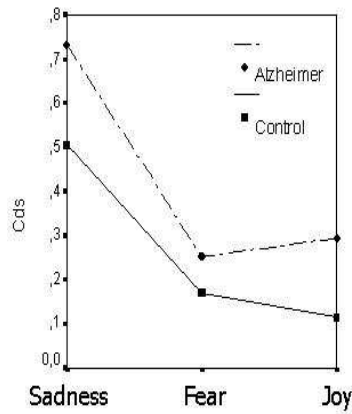


Fig. 2 neutral-emotion pairs (criterion)

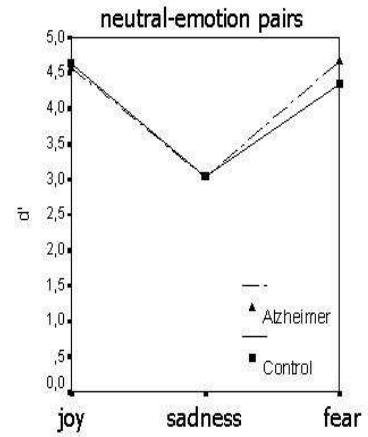


Fig. 3 d' patterns after controlling for cognitive differences (MMSE > 22)

sensitivity and response criterion obtained with N-E pairs, for AD and controls. The sensitivity index, used hereafter, is $d'sd$ (Macmillan & Creelman, 2005). The criterion measure corresponds to $C'sd$, derivable from the bias parameter k of the differencing model: $C'sd = (K - d' / 2) / d'$ (relative criterion: Macmillan & Creelman, 1991).

The graphics illustrate resembling patterns across groups, accompanied by quantitative differences between them. Lowered sensitivity and heightened criteria in the AD group does seem to be the rule. Differences between groups were shown highly significant for d' ($F(1,24) = 9.003$; $p = .000$) and marginally significant for $C'sd$ ($F(1,24) = 3.66$; $p = .067$).

Figure 3 presents patterns of $d'sd$ obtained with subjects scoring > 22 on the MMSE. As becomes apparent in the graph, group differences cancel out ($F(1,11) = .018$; $p = .894$). Same result was obtained by running an ANCOVA (all subjects) with MMSE as a covariate. E-E pairs (results not presented) also exhibited similar qualitative patterns and quantitative differences between groups. No clear support for a specific role of valence was found.

EXP II – Emotion intensities

Figures 4 and 5 compare AD and control subjects regarding sensitivity and response criteria obtained with intensity levels of Fear. As before, near parallelism of lines reveals similar patterns between groups, a result also shared by the other emotions considered (Sadness and

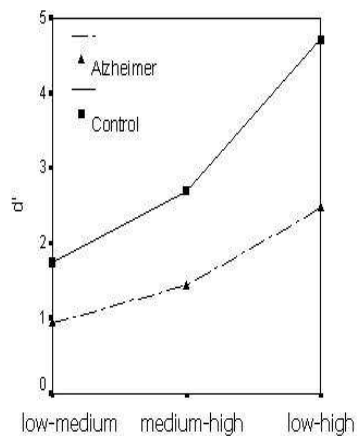


Fig. 4 Intensity levels of fear (d')

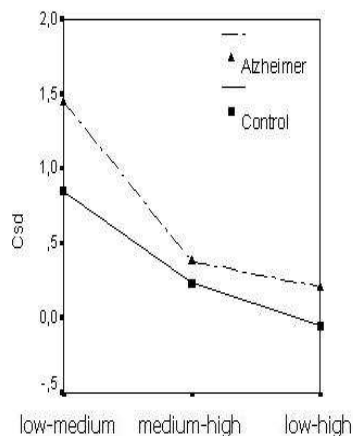


Fig. 5 Intensity levels of fear (criterion)

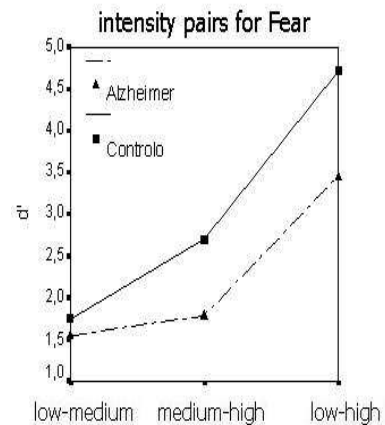


Fig. 6 patterns of d' after controlling for cognitive differences (MMSE > 22)

Joy, not presented). Except for Joy, where no differences between groups occurred, lower d' 'sd values and more severe C' 'sd (bias against saying “different”) in the AD group were again the rule. Differences in d' 'sd were significant ($p = .000$), while those concerning C' 'sd were not (only marginally significant for Fear: $p = .051$).

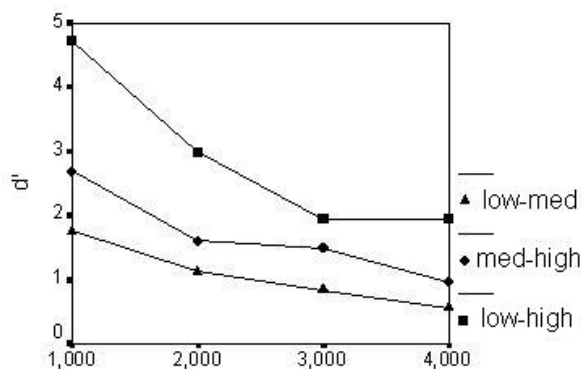
Figure 6 plots d' 'sd for Fear obtained with subjects scoring > 22 on the MMSE. Although reduced, group differences remain significant ($p = .010$). The same happened with Sadness ($p = .019$). An ANCOVA performed over all subjects with MMSE as covariate still revealed statistical significant differences between groups ($p = .024$) (not the case anymore with Sadness: $p = .076$). Put together, results suggest that lowered sensitivity of AD patients regarding the discrimination of emotional intensities, particularly of Fear, are at least to some extent dissociable from general cognitive deficit (as assessed by the MMSE).

Relations of d' 'sd (intensities) to the severity of AD (based on GDS scores)

Figure 7 plots sensitivity obtained with Fear intensities as a function of growing stages of severity of dementia (1 = controls: no dementia; 2-4 = increased stages of severity). A close to linear relation can be observed, confirmed by significant linear trends in polynomial contrasts ($p = .000$). Even if most clearly observed for Fear, the same was also true with Sadness ($p = .001$). Adding to its partial independence from overall cognitive decline, the ability of d' 'sd for intensities to track the course of the disease suggests its potential usefulness both as a diagnostic complement and as an index of clinical change.

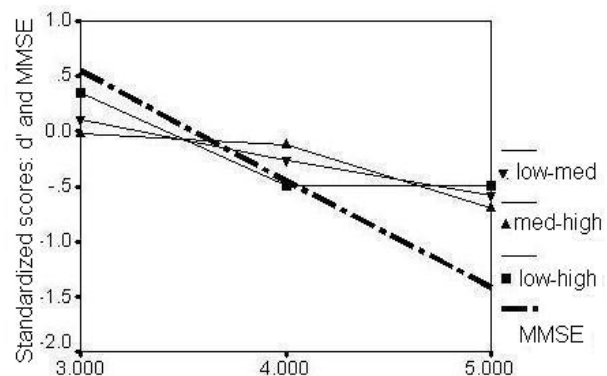
Comparison of d' 'sd (intensities) decline with general cognitive decline

Figure 8 simultaneously plots d' 'sd for Fear intensities and MMSE scores (general cognitive decline), in the ordinate, as a function of AD severity (3-5: mild, moderate, strong). To allow for legitimate comparison, sensitivity and MMSE indices were previously standardized (z scores). Linear trends, more clearly so for cognitive decline, can be observed for both indices (corroborated by significant linear contrasts). The most notable finding is the much steeper slope of overall cognitive decline. While this indicates that MMSE better reflects the course of dementia, it may also signal a further potential usefulness of the d' 'sd parameter. Cognitive assessment instruments quickly reach a “floor” at which they cease to differentiate between severity degrees: by contrast, the slower decline of d' offers the prospect of longer tracking of the course of disease, eventually all along the most severe stages of AD.



1-Control; 2 to 4 - severity based on GDS scores

Fig. 7 d' (Fear intensities) plotted as a function of severity of dementia



3 to 5 - severity based on GDS scores

Fig. 8 comparison between decline of d' 'sd (Fear intensities) and cognitive decline

Correlations between SDT parameters and neuropsychological and functional variables

Table 1. Correlation pattern between SDT parameters and other variables used in the characterization of AD patients (simplified through stepwise regression)

Global Cognitive Assessment	MMSE	d' sadness (low-high) (.590**); d' joy (.697**)
Specific Cognitive Assessment	Understanding of simples orders	C' sd joy (low-medium) (-.848**)
	Naming object	C' sd joy (low-medium) (-.848**)
	Writing	d' joy (.522*)
	Calculation	d' joy (.512*)
	Identification object	C' sd joy (low-medium) (-.848**)
	Cubes (WAIS)	d' sadness (low-high) (.506*)
	Copy of Cubes	d' sadness (low-high) (.627**); d' joy (.574*)
	Clock	d' sadness (medium-high) (.485*); d' joy (.502*)
	Interpretation of Figure	d' sadness (low-high) (.596**)
	Graphomotor initiative	d' fear (low-high) (.484*); d' fear (.472*)
	Motor initiative	d' fear (.630**)
Functional Assessment	Memory of numbers	d' sadness (low-high) (.447*)
	Information	d' sadness (low-high) (.447*); d' joy (.508*)
Functional Assessment	Barthel Index	d' joy (low-medium) (.634**)

Both SDT parameters (d' sd and C' sd) exhibited significant correlations with a number of cognitive, neuropsychological and functional measures used in the assessment of AD patients. Table 1 summarizes these correlation scores (after running a stepwise regression - variables admission criterion: prob $F \leq .05$; criterion for removing: prob $F \geq .10$). Main trends can be described as follows:

Regarding emotion qualities: (a) d' sd for Joy strongly correlates with the MMSE as well as with several measures of a cognitive and visuo-constructive character; (b) d' sd for Fear significantly correlates with measures of initiative (namely, motor and graphomotor).

Regarding emotion intensities: (a) d' sd for levels of expressed Sadness consistently correlates with MMSE and a large number of neuropsychological BLAD tests; (b) d' sd for levels of Joy consistently correlates with the Barthel Index, this being the only relation found with functional assessment variables; (c) d' sd for levels of Fear correlates with graphomotor initiative; (d) As the single criterion index to reach significant results, C' sd for Joy (low-medium levels) displayed strong negative correlations with language capabilities.

Conclusions

Overall, results unambiguously favour the existence of a deficit of AD patients regarding the discrimination of emotional expressions conveyed by faces. However, this conclusion requires qualifications. First of all, this deficit doesn't concern the qualitative features of performance (patterns), which remain the same in AD patients and controls, but quantitative differences between groups. Although mostly apparent in decreased values of sensitivity parameters, a consistent tendency for heightened criteria values can also be observed in AD patients, even if it only reaches significance episodically. The fact that differences in "attitudinal/decisional" parameters may be at work leaves a margin for the potential of

fostering emotional understanding in AD patients through rehabilitation programs (e.g., criteria training).

As for differences in d' 'sd between groups, a substantive distinction seems warranted between the discrimination of type/quality of emotions and of intensity levels of emotion. Whereas deficits in the former appear directly attributable to cognitive impairment, those concerning the later seem to be at least partially dissociable from general cognitive ability (assessed by MMSE);

Consistent linear declining trends as a function of AD severity were apparent in sensitivity parameters concerning levels of emotion intensity, especially of Fear (but of Sadness as well); as a rule, d' 'sd decline was shown less steeper than cognitive decline, which may turn out to be a valuable property, making possible to keep a longer track of the progression of dementia than usual cognitive assessment allows for.

A number of dependable correlations with potential diagnostic and clinical significance were found between SDT indices and neuropsychological (e.g., GDS, MMSE, B.L.A.D) and functional assessment variables (e.g., Lawton & Brody, 1969). These findings can offer selective guidance to further work aimed at the enhancement of differential AD diagnosis regarding other forms of dementia (e.g., vascular, fronto-temporal, etc.).

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